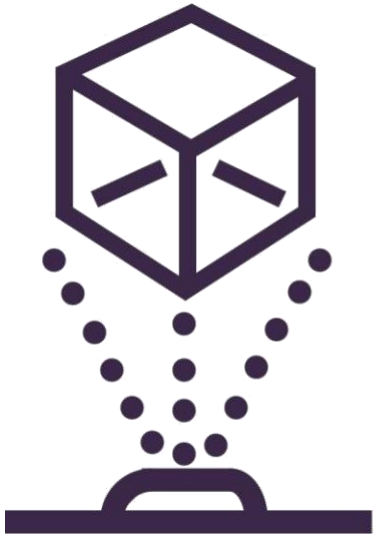

Augmentae

design reality

AUGMENTED REALITY MECHANICAL DESIGN SOLUTION
PROJECT PLAN

Team Number	sd-may18-02
Client	Deeksha Juneja, Founder E.S.A.R.C. L.L.C. (Augmentae)
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1 Introductory Material

1.1 ACKNOWLEDGEMENT

Our team is grateful to Ms. Deeksha Juneja for proposing this project as one of the many amazing projects for senior design. The idea behind the development of the [3]AR based CAD modelling software is interesting and intriguing to us all. We also would like to thank the client for their support in providing various market evaluations and overview on their vision with the product, supporting our work in class and trusting us with confidential data to accomplish the task. Furthermore, we would like to thank our advisor Professor Simanta Mitra who has agreed to guide us through the project.

We are all hopeful that we will be able to deliver on the project deliverables within the timeline as specified in this document and recorded for future use.

1.2 PROBLEM STATEMENT

For long we have been limited by technology and been constantly in attempt to overcome the barriers by developing new, more advanced and, efficient solutions for the problems. Today we recognize the same issue in the field of Mechanical Design. The technology that we have today is cumbersome and requires immense amount of training and tedious hours of work to do a simple task. As a team partnering with E.S.A.R.C., we are working to resolve the issue at hand.

On average a product designer takes around three hours to make a simple model, anywhere between week to two for medium size and months to years for a large project. This is not only inefficient but cruel and ethically lacking.

Our Solution designAR aims to resolve the challenges by providing them the tools that would help reduce the time and energy spent on designing. We aim to make the process more efficient and creative by providing features like freedom of movement and unique way of interaction with design.

Yet another challenge that we are solving with this tool is facilitating the customer business relationship by providing a portal for customers to view their design being built and monitor the progress. This would not only create transparency amongst the designers but also give a sense of security to their client.

Finally, we aim to provide through this software a platform for collaboration and community development amongst the designers. The idea is to create a collaborative

platform that would enable multiple designers to work on same model from across the world and be able to see each other's progress and assist wherever necessary.

Conclusively, designAR would be a product made for designers and their customer and will act as a relationship building platform where there is creativity, freedom of interaction and collaboration to accomplish the task at hand.

1.3 OPERATING ENVIROMENT

The Operating environment for designAR is not limited to the office cubicles like its counterparts. designAR comprises of two sets of sub-products. One being the software and other being the [3]hardware or VR/AR headset. Being a mixed reality technology, the user will have to keep in mind the boundaries of the surrounding.

[1] While using the headset equipped for VR only, our suggestion is that user would sit or walk in a confined boundary as limited by the respective headset sensors. On the contrary using an AR headset would give them more referential design process hence enabling them to walk around anywhere and be able to look at their design and interact with it in any way possible.

Finally, the user should keep in mind that the headset is a hardware equipment and exposure to dust and dirt is liable to cause certain level of damage along with any physical damage would render the system unusable. Keeping all the above said points in mind would encompass all the necessary Operation Environment for designAR.

1.4 INTENDED USERS AND INTENDED USES

This product is meant for product designers, mechanical engineers, architects, consulting designers, 3D designers, product evaluators, general customer etc. However, after intensive discussion with the client we have agreed to limit this product for product designers for the scope of this project. The product designer would be any person who is entrusted in an organization by their clients to design, model and, prototype the design for a new product.

The main uses which follow would be that the user should be able to transfer file and be able to view it in our system easily, we are also looking forward to developing a solution that provides them with ability to modify an existing model, and finally be able

to design the product from scratch. The designAR is required to functionally be able to provide the satisfaction of creation with feasibility of usage and without compromise in quality.

1.5 ASSUMPTIONS AND LIMITATIONS

Following are the major assumptions that we have taken on the project:

1. The user should be able to design anything with the product using basic tools meant to draw the 3D objects.
2. The project will assume that the tools are one of the headset used are widely used in the market.
3. The design quality will depend on the computer systems (Specifically the GPU card) that the user is using, and the parameters of hardware system being used at the time.
4. It is assumed that the user will have some experience with design software like AutoCAD or solid works and knows the basic concept of design process in terms of product design.
5. Being a mixed reality product, our assumption is that the users will have some sort of controller to be able to interact with the design.

Following are the major limitations for the scope of the project:

1. The product permits the user to be able to make a design and visualize within the frame of reference and visual capacity. The relative distance will be tracked with the position of the headset.
2. The product requires network connection, compatible graphics card like 1080 GTX by NVidia or something similar for best overall experience.

The user should have environment safe for VR design process. This would help account for any injuries related to the freedom of movement aspect of designAR

1.6 EXPECTED PRODUCT AND OTHER DELIVERABLES

The end -product will comprise of an enterprise software for CAD modelling where the user should be able to design their product and interact with it. This is a rapid prototype technology; therefore, the designers should be able to view and design their product as if it was the final prototype. We also aim to provide client integration and progress visualization. Finally, the final product is proposed to offer a collaboration platform for the product design process.

These are the respective deliverables for the project:

1. Common file visualization platform: The product should be able to provide a way to transfer Solid Works or AutoCAD file into a common 3D visualization platform.
2. Manipulation of the file: The user should be able to modify the file that has been created other software. Interact with it in 3D space and be able to modify it as and when necessary.
3. Designing from scratch: The user should be able to design the idea from scratch and be able to modify, interact and visualize their models.
4. Collaborative Platform: The software should incorporate multiple sessions from clients and the designers to be able to monitor the progress and be able to make a real-time change per suggestion as necessary.

2 Proposed Approach and Statement of Work

2.1 FUNCTIONAL REQUIREMENTS

There are following proposed functional requirements for the proposed project:

1. Design: The user should be able to design any model from scratch with the help of their AR/VR headset and controller. They should be able to recognize the appropriate 3D mesh they are working in and would be able to interact with the model.
2. Interact: The model designed should be able to react to the movements or interaction of the user, i.e. change in perspective either by movement of the user or the object itself.
3. Modify: The user should be able to modify an existing model and be able to make the changes temporary or permanent based on the approval. Additionally, they should be able to make the changes in the models created by their co-designers in our software.
4. Collaborate: Multiple designers should be able to make the contributions, visualize and help their coworkers as needed. This will create transparency in identification of any blockage in the funnel process. This is ideal for the team development and mentoring with students, interns and, new grads.

2.2 CONSTRAINTS CONSIDERATIONS

It is required to clearly document the code as per standard specification of IEEE and be able to clearly specify the files in the manual for development. The technology that is being used in the development would also be specified in the company internal documentation later created. There is a requirement to create a software architecture module for its overview and details.

Additionally, we are required to provide the final product specifications and product manual which would indicate the environment constraints for the software. This will give the company a basis to resume the development from the status at the end of the year and beyond.

2.3 STANDARDS

Standard protocols for this project will be as follows:

The client expects the coding standards to follow the Object-Oriented approach with design fundamentals appropriated by IEEE for the enterprise software application. This application is being made with consideration of expansion in future and therefore require a much planned execution and testing. Client expects that this could be the base software over which they can expand upon and therefore we require to follow coding guidelines as provided by the client. We are also expected to have a standardized documentation for the software explaining the details of the code and the methods written to implement various features that fall under the scope of this project.

2.4 TECHNOLOGY CONSIDERATIONS

The mechanical design solution in [1] Augmented Reality is a complex and an innovative project. Some of the strengths that can be noticed in this project is involved in the [1]AR/VR marketplace. This is an upcoming market that is going to be widely used a lot by consumer both in home and in enterprise market. The second strength that can be noticed is that the project is trying to simplify the design and rapid prototyping process for design engineers or architects. This project helps the designers implement and design projects from scratch in a 3d space instead of a 2d screen.

Some of the weaknesses we have noticed with this project is that there will be a learning curve for users to adapt the product we have developed. The UI might be a little complex to understand at first. The second weakness that can be noticed in this project is that the user will be confined to a limited space while wearing a headset to design objects, since most of the headsets are wired and the user can only roam around in certain areas.

Some of the tradeoffs that can be noticed in this project is that we even though the headset is wired, we do need the computational power of the desktop and there will be very low latency with the wired headsets. The second tradeoff that can be noticed is that even though there is a significant amount of learning curve for the users but the benefit of designing a 3d object in 3d space is easier than designing in 2d space.

2.5 SAFETY CONSIDERATIONS

[1] The only safety consideration at this point that we have would be while using a VR headset the user should keep in mind the boundary of their freedom of movement. This means that user should always be aware of their surrounding or switch to AR as necessary.

2.6 PREVIOUS WORK AND LITERATURE

[1] There has been previous work done in the field of [2]3D CAD modelling software. AutoCAD and Dassault Systemes have worked on developing a rendering model for their software. However, there has been very few developments on the aspect of designing in 3D space. We have also noticed that few companies that have been working on this technology for past few years have been able to release their product recently. This gives us certain support to build our project and helps us get involved in the race to accomplish this task.

2.7 POSSIBLE RISKS AND RISK MANAGEMENT

We have following issues that need dealt with for the success of the project:

1. The availability of headset and expensive cost makes it hard to test it.
2. The sacrifice between the accuracy and details would be a struggle.
3. Not having a mechanical engineer on team with experience on already existing products in market is a letdown.

We have been able to manage most of the setbacks including arranging a headset and renting it out from the ISU Computer Science department. Our client has also arranged a mechanical engineer to work with us on testing the product and delivering on the requirements as needed.

2.8 PROJECT PROPOSED MILESTONES AND EVALUATION CRITERIA

Throughout the time, following are the main milestones that we wish to accomplish:

Milestone I: File Transfer and Data Compression for designs.

Milestone II: Create 3D mesh for render, Rendering of design objects in the 3D mesh

Milestone III: Append to the design with basic tools, UI improvisation, Client feedback

Milestone IV: Create more tools for designing from scratch.

Milestone V: Design architecture for design file size reduction and improving efficiency, client feedback

Milestone VI: Additional add-ons for making the design process interactive or responsive to gestures and input through various means.

Milestone VII: Integrating multiple sessions logging into the workspace with auto save feature, client feedback

Milestone VIII: Testing and debugging

Milestone IX: Project Demonstration and Client Presentation

Milestone X: Final feedback improvement and improvisation

2.9 PROJECT TRACKING PROCEDURES

To track the progress of the project, we would use slack and GitLab issues to keep up with the work on the project. We are also planning to hold sub-team meetings where we can discuss our work as sub sections of whole team. Moreover, we are planning to have a team meeting every week, client and advisor meeting every two weeks.

Additionally, the milestones and deadlines are one of the most important ways we can evaluate our progress throughout the year. Moreover, check on the team's progress by each of the team members would be an additional check.

2.10 OBJECTIVE OF THE TASK

The goal of the project is to deliver a software which is capable of rendering and creating a design model in 3D space. The deliverable is an enterprise software that would help product designers, architects and mechanical engineers in better designs and processes.

The product is divided into two sections. One being, where the user can use mixed reality headset and a software for the headset, and another being the complete software itself to render the graphic on headset available to the user.

2.11 SCOPE OF THE TASK

Currently, this AR project is in the planning stage with the initial implementations around the corner. This project is to be designed to import SolidWorks files, so they can be rendered in 3D Space. Our initial focus is to make sure that our project can properly import and render these files, as future additions to the project will not be possible if we cannot render these models in the first place. For viewing these models in 3D space, we will first make sure that our project is compatible with the VR/AR headset provided to us, and then expanding compatibility once we are confident the project is operating consistently.

[5] Once this is completed, there are a couple additions we intend to add to the project. First is the ability to manipulate the 3D models rendered by the project. We will start with basic manipulations such as turning/rotating individual models as well as increasing or decreasing the size. Second, the ability to create new models with our project will be extremely useful because the user will be able to create/manage his or her work using our project. Finally, for future use as mentioned before, making the project compatible with different headset types will make our project more appealing in every aspect because there won't be nearly as many limitations accompanying our project. If we meet all these goals, then we will attempt adding more options such as stress testing models, adding options such as material types etc.

2.12 PROPOSED SOLUTION

There are multiple ways to approach the problem presented to us in the form of this project. According to the milestones we have following diagram represent the ideal overall architecture of the software.

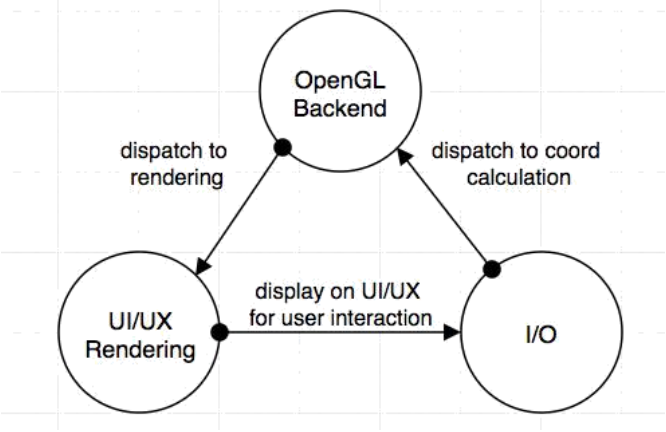

Figure 1 High-Level Software Architecture Diagram

We can see above that the overview shows that (Figure 1) the user will interact with design using input/output tools of their respective headset. This will in turn send the changes as packets to the backend to process which will then send it back to UI/UX for rendering so that the user can interact with the tool.

Below is another diagram for the backend pipeline for software architecture of the designs.

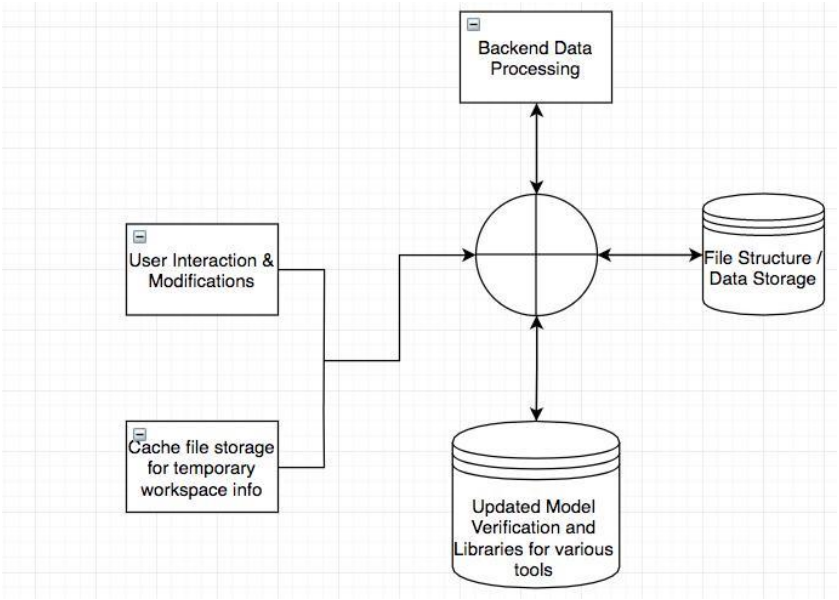

Figure 2 Model for the architecture of the design process

As mentioned in figure 2, to keep the process synchronous, we will have a dispatcher and a listener to the changes made to file systems in database. Furthermore, we will have multiple patches every given time to make the most use of resources. Additionally, the UI and interaction would be looking at multiple databases.

Conclusively, the software architecture is still under discussion amongst us, but we are rapidly coming up with ideas that would help us make the best software deliverable for this project.

2.13 EXPECTED RESULTS, VALIDATION AND TEST PLANS

The following points are the requirements for our project along with the tests that will be conducted on them:

Transfer object file from Solid works/AutoCAD to our software to render in 3d space: For this requirement, we will test multiple models from solid works or AutoCAD to see how the model is getting rendered. We will also conduct system diagnostics to see how our software is utilizing the system resources. This should expectedly be real-time and should not lag as the user is designing.

Manipulate existing 3d objects using our software: For this feature, we will test it by adding simple textures to the existing model and running unit test side by side to see if we were successfully able to manipulate the model on some scale.

Create a 3d object from scratch: For this feature, we will conduct rigorous unit testing to see if the coordinate system is getting translated correctly and, we will conduct tests on hand gesture and motion tracking.

Real time collaboration: For this feature, we will conduct tests with https protocols and check if the connection between different users is constant all the time and reduce the latency as much as possible.

Conclusively, most testing will be done in terms of the operation and time lag of command execution. We can benchmark it against the standard soft wares we have like SolidWorks and time the rendering of a standard model across the platform. This will help us establish a sound data on the efficiency and resourcefulness of our software.

3 Estimated Resources and Project Timeline

3.1 PERSONNEL EFFORT REQUIREMENTS

TASKS	ESTIMATED TIME	EXPLANATION
Transfer 3d object file to Design AR	The estimated time for this task is about 1.5 months.	We will have to figure out the configuration of the 3d object file and make it compatible to render it on openvr.
Create 3D mesh for render, Rendering of design objects in the 3D mesh	The estimated time for this task is about 3 weeks.	We will use OpenGL to render 3d mesh
Append to the design with basic tools, UI improvisation, Client feedback	The estimated time for this task is about 3 weeks.	We will have to work with Openvr to design the UI
Create more tools for designing from scratch.	The estimated time for this task is about 2 months.	We will work with opengl and openvr to add more features
Design architecture for design file size reduction and improving efficiency, client feedback	The estimated time for this task is about 1 month.	We will have to research and develop a solution in python/c++ to improve file size reduction.
Additional add-ons for making the design process interactive or responsive to gestures and input through various means.	The estimated time for this task is about 2 weeks.	We will have to implement this feature using openvr and opengl.
Integrating multiple sessions logging into the workspace with auto save feature, client feedback	The estimated time for this task is about 2 weeks.	We will have to make a small network socket in openvr so that customers can interact with each other.

Testing and debugging	The estimated time for this task is about 2 weeks.	We will have to deploy unit tests and monkey test with our project to find bugs
Project Demonstration and Client Presentation	The estimated time for this task is about 1 weeks.	We will be demonstrating the product to our customers.
Final feedback improvement and improvisation	The estimated time for this task is about 1 weeks.	We will be making last minute improvisations to our product.

3.2 OTHER RESOURCE REQUIREMENTS

We will require a laptop or a desktop with a minimum graphics card of GTX 980 run our simulation and support an AR headset. We will also need a Microsoft HoloLens or a HTC Vive to run the product.

3.2 FINANCIAL REQUIREMENTS

The HTC Vive will cost us about 800 dollars and the Microsoft HoloLens will cost us about 2000 dollars. The desktop to run this hardware will cost us about 1500 dollars.

The financial requirements are a significant constraint for the project as we dive further into the project. We are aiming to bootstrap our resources to get items of our use either borrowed or rented out.

3.3 PROJECT TIMELINE

Following is the schedule that we are planning to follow to deliver on the requirements of the project. The Gantt chart shown below demonstrates the ideal time for the delivery of various milestone as mentioned in section number 2.7.

** This Gantt chart is for the fall semester only

Task Name	Start	Finish	Assigned To	Duration
File Transfer & Data Compression	09/19/17	09/27/17		**7d**
Research on File types and CAD DS	09/19/17	09/27/17	Bhimesh	**7d**
Research on AR UI Designs	09/19/17	09/27/17	Cole	**7d**
Research on Unity	09/19/17	09/27/17	Ryan	**7d**
Research on OpenGL vs OpenVR	09/19/17	09/27/17	Cal	**7d**
Research on Graphics Rendering in CAD softwares	09/19/17	09/27/17	Vaibhav	**7d**
3-D rendering & File Conversion	09/27/17	10/11/17		**11d**
File DS creation	09/27/17	10/11/17	Vaibhav	**11d**
Conversion of existing DS to our	09/27/17	10/11/17	Cal	**11d**
Creating basic UI for the headset	09/27/17	10/11/17	Cole	**11d**
Creating 3D Mesh for various devices	09/27/17	10/11/17	Bhimesh Chauh	**11d**
Rendering the Data on the headset	09/27/17	10/11/17	Ryan	**11d**
Basic Editing and Rendering & Client Review	10/11/17	10/25/17		**16d**
Add basic tools to UI	10/11/17	11/01/17	Ryan	**16d**
Scaling feature for the object	10/11/17	11/01/17	Cole	**16d**
Additional drawing on the object	10/11/17	11/01/17	Bhimesh	**16d**
Optimization for speed and processes	10/11/17	11/01/17	Vaibhav	**16d**
Testing	10/11/17	11/01/17	Cal	**16d**
Completion of basic toolset for editing and designing	10/11/17	12/27/17		**57d**
Tools for editing	10/11/17	12/27/17	Bhimesh	**57d**
Tools for contouring	10/11/17	12/27/17	Cole	**57d**
Tools for subsections and cropping	10/11/17	12/27/17	Ryan	**57d**
Tools for embossing	10/11/17	12/27/17	Vaibhav	**57d**
Testing and Client Review	10/11/17	12/27/17	Cal	**57d**

Figure 3 Gantt chart for agile development cycle

4 Closure Materials

4.1 CONCLUSION

[4] This project is a major milestone for the future of AR and designing technology. There are still many possibilities to implement and improve the AR technology and we are one of the possibilities. In the current designing world, a product engineering would take a long time to design a model in a confined 2D space and the collaboration between multiple designers is difficult and inefficient. As for our project, we are working towards breaking down this barrier with the VR/AR technology. [2]Our team will enable the designing and human collaboration from all around the world for CAD modelling with most or all the VR headsets in 3D space.

One of our solutions is to allow 3D object files to render in the VR headset for a head start. After that, we will be appending an UI/UX interface and some basic designing tools for the VR headset and sensors to make the designing and the human collaboration in the 3D space possible. More additional add-ons such as designing tools and efficiency improvement will be conducted upon success of the previous steps. Throughout the process, testing and debugging will be carried out to ensure the functionalities of the equipment and the project. As a conclusion, we believe that we are the team for this project to be successful as we move forward to our goals.

4.2 REFERENCES

[1] Team, 3DxBlog. “3DxBlog.” Augmented Reality: The Future of CAD Design, blog.3dconnexion.com/augmented-reality-the-future-of-cad-design.

[2] Serdar, Tumkor. Integration of Augmented Reality into the CAD Process. ASEE, 2013.

[3] ENGINEERING.com. What Is Augmented Reality and How Can Engineers and Designers Use It? > ENGINEERING.com, www.engineering.com/IOT/ArticleID/11873/What-Is-Augmented-Reality-and-How-Can-Engineers-and-Designers-Use-It.aspx.

[4] Augmented Reality (AR) Is The Future Of CAD Design, www.directionsmag.com/pressrelease/5640.

[5] “Installing the OpenVR SDK.” Meta Devcenter, http://devcenter.metavision.com/get-started/software-setup/installing-the-openvr-sdk