



Augmentae

design reality

AUGMENTED REALITY MECHANICAL DESIGN SOLUTION DESIGN DOCUMENT ^[2]

Team Number	sd-may18-02
Client	Deeksha Juneja, Founder E.S.A.R.C. L.L.C. (Augmentae)
Advisers	Dr. Simanta Mitra (ISU Computer Science Department)
Team Members/Roles	Bhimesh Chauhan – Team Facilitator, Backend & Data Eng. Cal-Van Vert – Data/Pipelining Engineer Cole Chapin – User Interface Engineer Ryan Luckinbill – User Experience Engineer Vaibhav Malhotra – Documentation Lead, Backend Developer
Team Email	sdmay18-02@iastate.edu
Team Website	http://sdmay18-02.sd.ece.iastate.edu/
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Table of Contents

INTRODUCTION.....	2
1.1 ACKNOWLEDGEMENT	2
1.2 PROJECT STATEMENT	2
1.3 PURPOSE	2
PROJECT GOALS.....	3
PROJECT DELIVERABLES	3
DESIGN SPECIFICATIONS.....	4
PROPOSED DESIGN / METHOD	5
DESIGN ANALYSIS.....	5
HARDWARE / SOFTWARE.....	6
INTERFACE SPECIFICATIONS.....	6
FUNCTIONAL TESTING.....	6
NON-FUNCTIONAL TESTING.....	7
MODELING AND SIMULATION.....	7
IMPLEMENTATION ISSUES AND CHALLENGES	7
NATURE OF CONTENT	8
TECHNICAL APPROACH.....	9
PROCESS DETAILS.....	10
DESIGN TESTING/IMPLEMENTATION	10
CONCLUSION.....	11
REFERENCES.....	11

INTRODUCTION

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 AR (Augmented Reality) based CAD (Computer Aided Design) 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 Dr.Simanta Mitra who has agreed to guide us through the project.

1.2 PROJECT STATEMENT

The project's goal is to build a mixed reality (Augmented Reality/Virtual Reality) system where design engineers/ architects can import complex 3D CAD designs or create one and manipulate those designs in mixed reality space. All the task can be accomplished by wearing any virtual reality headset like the Oculus Rift or the HTC VIVE^[1].

1.3 PURPOSE

Currently, CAD designers can design complex 3D designs on a software like Solidworks, AutoCAD, etc. One of the major limitations that can be noticed is that the designer is limited to a 2D screen for designing 3D objects. The project will solve this problem by letting designers create and modify complex CAD designs rapidly with a very low learning curve. Overall, this project will be useful for Rapid Prototyping.

PROJECT GOALS

The goals for the project are:

- Import existing 3D CAD models
 - Can import CAD models from any CAD modelling software.
 - Can manipulate existing CAD models in Virtual Reality space.
- Create complex 3D CAD Designs
 - Can create models from scratch.
 - UI will have tools that will be like a lot of CAD modelling software.
- Real Time Collaboration
 - Users and Designers can collaborate and work on the same design at the same time, virtually.
 - Will help in presenting prototypes to clients.

PROJECT DELIVERABLES

The project deliverables throughout this project as outlined before in the project plan are the following:

1. User should be able to transfer their design files from respective software into the AR/VR headset using our file conversion and mapping system.
2. User should be able to augment the design imported into the AR/VR headset. In addition, the user should be able to accentuate the ideas on the same model to improve and make formatted copies of the model to go back to (retraceable designs).
3. The User should be able to collaborate in the design process throughout the process with colleagues in real-time irrespective of the geographic location.
4. The client on the user end should be able to monitor the progress of the design process and be part of improvisation and suggestions wherever possible.
5. The user should be able to present the prototype to clients in any form - mobile, VR/AR, 2D model or 3D design.

In conclusion, the above-mentioned points are counted as expected project deliverables by the clients and are subjected to change as the project progresses.

DESIGN SPECIFICATIONS

There are few functional and nonfunctional requirements that has come to light in our meetings with the client and our advisor. Amongst the deliverables as discussed in the previous sections, we have arrived at an agreement to form this as the minimum viable completion of the project that is specifically required by the client. The points are as mentioned below:

1. The client wants to be submitted a project that could be functional to bare minimum of accentuation of design and a collaborative platform for designers, architects, engineers to work on.
2. The client and advisors have agreed on the said segregation of the project in the project plan with different phases of development and will henceforth become a functional requirement.
3. It is required of the team to produce an accountable and responsible code (IEEE standard) for client to build up on the given application and its completion after the end of this project.

There are few non-functional requirements of the client that can be done if the time is available to do so. The few nonfunctional requirements are:

1. The software application should be able to have a way to create a fast-responsive model even for the complex structures. Therefore, coming up with the adequate data structure to hold the data is important.
2. The client would appreciate if we are able to incorporate most of the available software into our application so that the users are better able to transition into the application use.
3. Additionally, coming up with a way to make the platform responsive to the surroundings is another issue that we must discuss with clients and understand more about before we finalize if we will be able to provide for.

Conclusively, there are many requirements of the client and each of them are carefully being evaluated and discussed with the client and advisor to make this project a success.

PROPOSED DESIGN / METHOD

The implementation that our team has designed so far allows us to be able to parse files from other CAD modules into our own software. We have been able to design a 3D map that creates a sphere on a common coordinate system. This can then be rendered on the AR/VR system. The file parser (parses an stl file) gets the coordinates for triangle strips that every 3D CAD model is made up of. The program then sends this information to the OpenGL (Graphics library) program, which in turn will render these triangle strips, thus rendering a complex CAD model. The rendering program will work in tandem with the virtual reality rendering program. We need to implement a VR rendering program because it will calculate the spatial and 3D movements of the user and let the user observe a model from all perspective. We have found a way to implement this program using OpenVR library^[3] which will let us implement a VR application on a lower level so that we have more flexibility with the application.

Currently, our project can parse an exported stl file from SolidWorks or AutoCAD, and render the 3D CAD on the VR headset, but we cannot manipulate the design or interact with in the VR space. The next step to implement this would be to use OpenVR^[3] as mentioned above and also research about Object manipulation and real-time connection between multiple users. We will also be implementing a UI (User Interface) which will help the users design or manipulate a CAD design.

DESIGN ANALYSIS

The team has decided to use HTC Vive^[1] for our testing and development since we can have it for the whole semester by the SSG IT department of Department of Computer Science. For the first step, we are trying to parse the triangle vertices from a stl file which can be created from any CAD designing software and the triangle vertices will be used to plot a 3D model. Now, we are still trying to design a working stl parser for rendering use. The current parser can extract all the triangle vertices, but we still need to improve it so that the extracted triangle vertices will be structured and organized.

HARDWARE / SOFTWARE

The software for this project will be developed by using OpenGL in Python and OpenVR^[3] in python. The project will use HTC VIVE^[1] to display and render complex 3D designs and will use the VR headset's joysticks to let the users manipulate the 3D CAD designs.

INTERFACE SPECIFICATIONS

The team managed to check out a HTC VIVE^[1] for a whole semester from our SSG IT department of Department of Computer Science with the help from our advisor, Dr. Simanta Mitra. We will be using this HTC VIVE^[1] to test our software code written in python 2.7. To render a 3D model, we are trying to get a high-performance laptop equipped with the minimum requirements needed by the VR headset such as HTC VIVE^[1]. However, this has not happened thus far this semester and when using the VIVE^[1], we are running it off an underpowered laptop.

FUNCTIONAL TESTING

The testing for any functional requirements will be done by an internal member of the team on two fronts and an external person provided by the client. The first front for internal testing would be done on evaluation of software performance in time space and graphical rendering complexity. We are also aiming to reduce the latency and increase the responsiveness by a significant factor which is an important aspect of the project requirement.

On the second front we are going to test the software out on the hardware. Having to maintain a frame rate of 120 and above per seconds is vital for the success of this project. We will also be testing on responsiveness of the model to various commands and features as we add on to the application.

We are also being provided an external mechanical engineer who would be taking our application on a "test-drive" to make sure everything is working perfectly and well. Once we have our feedback we will work on improving the product as necessary and according the plan.

NON-FUNCTIONAL TESTING

Our minimum goal for now is to make sure that the HTC VIVE^[1] can take in our desired inputs which are the triangle vertices of an stl file and render them to the HTC Vive^[1]. The smoothness of the rendered 3D model will depend on our laptop or desktop hardware features and the efficiency of our code. We will make sure that the headset's rendering will not fail unless there is an external interference such as power loss. We will also make sure the image rendered in the VR headset is exactly what we want it to be in our program or code.

MODELING AND SIMULATION

We will use OpenVR^[3] to simulate our project before we test it on the HTC Vive. Since we only have one Vive for our group, each member will be able to use the simulator when the Vive is not available. The simulator will be used to view outputs as they would appear on the Vive. This means it would test outputting to two displays, one for each display in the Vive and give us an accurate representation of the output without needing any different hardware.

The simulator built into OpenVR^[3] will allow us to test our code as well as the framerate and quality of the display. We need our code to be optimized and quick to prevent motion sickness and the simulator will help quicken code production to prevent that.

IMPLEMENTATION ISSUES AND CHALLENGES

There are multiple implementation issues that we are expecting as we are working on creating this software. We are expecting to hit a glitch on various fronts including but not limited to make this product testable with real engineers. One of the biggest concern that we have is that of performance. We are expecting our software to be able to work at blazing fast speed transmitting a data of around more than 500 MB at a time. This capacity is something that we are looking forward to reducing in order to make it easier for us to process more information. Furthermore, we are facing with the issue of being able to make the software work for every format available in the market. The challenge is that the system that other product depend on might not work very well with ours for which we might have to design a separate architecture with very similar principles.

NATURE OF CONTENT

The scope of the project is using OpenVR^[3] and python to develop a way to design products. We will use libraries and develop code for the HTC vive^[1] such that we can use virtual reality to its fullest in our product. Virtual reality is a very new technology with it only coming into light in the past few years. Our product will be using virtual reality to expand a traditional desktop when viewing or designing a product.

We will also be building on the typical design solution of AutoCAD or Solidworks which are a few different platforms used to design a physical product. Our goal is to use can start a design from scratch and take previously designed files from AutoCAD or Solidworks and import them into our project to be viewed or edited.

Our product will allow designers to view prototyped items without needing to physically print or take time to create a prototype. Rather, they can import their file into our software and view the item in Realtime.

TECHNICAL APPROACH

To properly approach this project, the team decided that the project needed to be broken down into 3 key phases:

Phase 1: Phase one contains a couple important characteristics that we need to work properly for the rest of the project to be successful. In phase one we are dealing primarily with how files will be read by our project. Since we are working with both SolidWorks, and AutoCAD, we are first going to have to decide which file type it is before we do anything else. Once that has been established, we can create and test code that will interpret these files, so we can recreate them in 3D space. This part is very important because in the future, it is possible that this project will be working with extremely complicated files, therefore we need to be careful with programming this phase of the project otherwise we might run into trouble down the road without even knowing it.

Phase 2: Phase 2 focuses on expanding on phase 1. Now that we have a project that can import SolidWorks and AutoCAD files, we want to be able to do something with these files. Since we are still in the early stages of the project, the focus of this phase is to make sure we are rendering basic objects properly, along with the addition of a VR headset. This is where OpenGL and our VR headset will come into play. Once we know everything is working smoothly on a very basic level, then we can begin to experiment with more complex designs.

Phase 3: Phase 3 will be an open-ended phase. Once phase 1 and 2 are working smoothly, we are confident that additions to the project will become easier. Phase 3 is where we begin to turn the project into something that has a variety of tools that could help with project management.

This varies from editing sizes to giving objects material values and stress values. Initially, we would like to implement ways to transform, move, create, and delete objects. Once this is completed, then we can continue to add more functionality.

PROCESS DETAILS

Currently phase 1 of the development process, the current project consists of mainly C++ and python code, which is being used to parse files so that they can be rendered in 3D space. The priority focus at this point is to do a lot of debugging to make sure the data parser created is bug free. Since the file interpretation and data parser are not fully operational yet, things that are absent from the project currently are the VR implementation and graphics rendering. Currently we are only working with parsing files so that we can recreate them.

Later stages of the project will incorporate both the graphics rendering and VR implementation, which will allow 2D SolidWorks and AutoCAD files to be rendered in 3D space.

DESIGN TESTING/IMPLEMENTATION

For design testing, we are planning on using TDD (Test Driven Development) approach to write unit tests for different modules of the program that is tailored for individual use cases and model data from other softwares such as our stl parser and graphics rendering program to iron out any bugs that are present in our program. We are also planning on testing our system integration. Since, our project consists of 3 programs that are working in tandem with each other, we plan on checking if the interface between these programs is working correctly. We will test if the data is being processed correctly and the system is performing as expected. Also, we will deploy automated testing using tools such as selenium, Boost test to deploy commands on the software and log the break points in UI and logic. We are also going to let a mechanical design engineer test our software so that we can get feedback from them on as to what changes and improvements we can implement in our project.

Once we have all of our project implemented, we will return to each part and search for any optimizations that we have not found when creating the project. The reason for this is that the VR application has to be quick and responsive to prevent motion sickness and or dizziness that comes with low response.

CONCLUSION

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. 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. As a conclusion, we will do our best to get the minimum requirement done and work ahead this semester. This is rendering a stl file to a VR headset and being able to do some basic modifications to it.

REFERENCES

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