Project Title

DESIGN DOCUMENT

Team sdmay20-30

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Executive Summary

Development Standards & Practices Used

1. IEEE development standards
2. Digital design development standards
3. VLSI design development standards
4. Lab safety development standards

Summary of Requirements

1. Setting up a simple 3D printing platform, light source, etc.
2. Establishing DMD Array to reflect UV light as a patterned light source.
3. Building an X-Y-Z Motorized System to make sure the stage can move layer by layer.
4. Designing the Graphical User Interface to upload the file which users want to print by our 3D printer.
5. Focusing on how to design a driver that could transfer the pattern from the GUI to DMD.
6. Testing our product and making continuous improvement.

Applicable Courses from Iowa State University Curriculum

EE 201. EE 230. EE 311,EE 332, EE 432, EE 531, Cpre 281. Cpre 288, Coms 228, Phys 221, Phys 222, Coms 227, Chem 167

New Skills/Knowledge acquired that was not taught in courses

1. SolidWorks
2. Stereolithography
3. Budget management

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Figure 1. Project plan

Time	Tasks
Oct. 2019	Setting up simple 3D printing platform, light source, etc.
Nov. 2019	Establishing DMD Array to reflect UV light as patterned light source.
Dec. 2019	Building a X-Y-Z Motorized System to make sure the stage can move layer by layer.
Jan. 2020	Still working on 3D Motorized Stage. Calculate cure speed and and Building head position.
Feb. 2020	Designing the Graphical User Interface to upload the file which users want to print by our 3D printer.
Mar. 2020	Focusing on how to design a driver which could transfer pattern from the GUI to DMD.
Apr. 2020	Testing our product and making continuous improvement.
May. 2020	Final presentation and document about our product.

1 Introduction

1.1 Acknowledgment

We would like to thank our advisors Meng Lu and Liang Dong for technical assistance and support. We would also like to thank our student advisor Le Wei in advance for helping to guide our team.

1.2 Problem and Project Statement

This project aims to build and demonstrate a 3D lithography system by using the existing digital mico - mirror array and the inverted microscope in our lab. 3D lithography system is important in many fields, for example, it could be used to develop microscale biorobots, microfluidic devices, and metamaterials.

The project consists of three major tasks for us:

1. building an X-Y-Z Motorized System.
2. developing the GUI for users to generate patterns and integrate the system.
3. Testing and exam our products, then make continuous improvement.

The output of our design:

1. Well - worked 3D lithography printer.
2. Functional 3D lithography system.

1.3 Operational Environment

The 3D printer must be placed and operated in an environment at room temperature without strong light since different lights will affect the intensity and focus of the UV source to interfere with printing accuracy. Avoid direct contact between the skin with the liquid in the print container.

1.4 Requirements

1. Setting up a simple 3D printing platform, light source, etc.
2. Establishing DMD Array to reflect UV light as a patterned light source.
3. Building an X-Y-Z Motorized System to make sure the stage can move layer by layer.
4. Designing the Graphical User Interface to upload the file which users want to print by our 3D printer.
5. Focusing on how to design a driver that could transfer the pattern from the GUI to DMD.
6. Testing our product and making continuous improvement.

1.5 Intended Users and Uses

Our design is intended for various users:

1. Manufacturing applications:
   Mass customization, Rapid prototyping...
2. Medical applications:
   Bio - printing, Medical devices...
3. Industrial applications:
   Soft sensors and actuators...
4. Sociocultural applications:
   3D selfies, Art, Education...

1.6 Assumptions and Limitations

Assumptions:

1. Up to 95%, accurate microstructures can be performed.
2. Easy to perform for users.
3. High-intensity UV light source may increase the efficiency of the printer.

Limitations:

1. The surface texture is generally too rough.
2. It is difficult to 3D model.
3. Machines are generally too slow.
4. Generally a few colors.
5. The size of the printed object must be smaller than the size of the platform.

1.7 Expected End Product and Deliverables

Expected End Product:

1. Optical imaging system.
2. GUI.
3. X-Y-Z Motorized System.

Expected End Deliverables:

1. A functional 3D lithography system

2. An established standard operation procedure to print 3D microstructures using UV sensitive polymers

3. 3D microstructures printed using the developed system

2. Specifications and Analysis

2.1 Proposed Design

We are currently working on the light source, DMD array and find suitable resin. We have set up a sample GUI and chosen a suitable platform.

2.2 Design Analysis

We created a sample GUI and it worked. Because we want our users to upload a file from the interface and we can make that happen. We want to find a suitable DMD array to be continued because DMD array is the key element to generate a suitable pattern for lithography. A suitable DMD array can be **identified by computer easily**, but we get the DMD array from the projector, it's a **little bit expensive**.

2.3 Development Process

Basically, we followed the Water Model. In our project, it can be divided into several phases. We must make sure each phase must be completed before the next phase can be began. For example, only we solved the DMD array issue, we can develop a GUI to drive the DMD array.

2.4 Design Plan

Our current plan is to find a suitable DMD array which can be used in our project because the DMD array is the key element to solve the project. And then we can have a plan for the next step.

3. Statement of Work

3.1 Previous Work And Literature

Wu, C., Yi, R., Liu, Y., He, Y. and Wang, C. (2016). *PDF*. [ebook] Daejeon, South Korea: IEEE, pp.2155-2156. Available at: https://ieeexplore.ieee.org/document/7759338 [Accessed 2 Nov. 2019].

This article shows a way to build a 3D printer by using delta structured platform. It shows the mechanical structure, control module and a prototype of delta DLP 3D printer. One aspect from this article that is similar to our project is to build a X-Y-Z Motorized System and platform to make sure the stage can move layer by layer(From bottom to top).

de Beer, M., van der Laan, H., Cole, M., Whelan, R., Burns, M. and Scott, T. (2019). *Rapid, continuous additive manufacturing by volumetric polymerization inhibition patterning*. [online] ScienceAdvance. Available at: https://advances.sciencemag.org/content/5/1/eaau8723 [Accessed 3 Nov. 2019].

This article describes the chemical technology for 3D printing called photolithography, which is a process used in microfabrication to transfer pattern in to substrate. In our project, the photosensitive material exposed under UV light will change their properties to “print”. The photoinitiator can creates reactive species (free radicals, cations or anions) when exposed to radiation (UV or visible). The photopolymer (light-activated resin) can change its properties (become hardened polymeric material in our project) when exposed to light.

3.2 Technology Considerations

The strengths: We could implement a structure that the platform can be moved both vertically and horizontally, we hope we could use a delta structure in the future.

The weakness: When one of my team members were working on UV LED, he found that 4500’s Light engine design had different versions, so the shape of the LED board was a little different. Based on what we met, we are going to try an external LED, we basically mount the LED outside.

Trade-offs: The major trade-offs was to use a new projector instead the old one in the lab, we order a new projector form TI, and we need to change the light source to only UV lights. In this way, we could save plenty of time. We also found that we could reduce Voxel size by adding two optic shims inlight engine. It is a good way to get the suitable patten from the projector.

3.3 Task Decomposition

i) Setting up a simple 3D printing platform, light source, etc.

ii) Establishing DMD Array to reflect UV light as a patterned light source.

iii) Building an X-Y-Z Motorized System to make sure the stage can move layer by layer.

iv) Designing the Graphical User Interface to upload the file which users want to print by our 3D printer.

v) Focusing on how to design a driver that could transfer the pattern from the GUI to DMD.

vi) Testing our product and making continuous improvement.

3.4 Possible Risks And Risk Management

For now, we do have a limitation on hardware, due to the fact that we need to set our DLP on a flexible angle to the mirror, so we plan to design a box by using SolidWork to help our DLP fixed, the problem is that none of my team members have a good knowledge on SolidWork, we will keep learning.

3.5 Project Proposed Milestones and Evaluation Criteria

Milestones:

28/9: Define project goals and design schematic

13/10: Identify parts

25/10: Motorized stage prototype

01/11:DMD array projector prototype

Evaluations:

1 The schematic must be met the requirements of the project

2 Parts used must fit within budget

3 Stage prototype should move smoothly and along X-Y-Z axis

4 DMD array should reflect Uv light as patterned light source

3.6 Project Tracking Procedures

We are using slack to tracking our conversation beyond meeting time, we also post what we have done and what problem we meet during our work.

3.7 Expected Results and Validation

We aim to build and demonstrate a 3D lithography system by using the existing digital mico - mirror array and the inverted microscope in our lab. The expected results should be Well - worked 3D lithography printer and a Functional 3D lithography system.

One way to confirm a high-level performance is to see if our 3D lithography printer can print a vivid products which is required by our clients.

4. Project Timeline, Estimated Resources, and Challenges

4.1 Project Timeline

Time	Tasks
Oct. 2019	Setting up simple 3D printing platform, light source, etc.
Nov. 2019	Establishing DMD Array to reflect UV light as patterned light source.
Dec. 2019	Building a X-Y-Z Motorized System to make sure the stage can move layer by layer.
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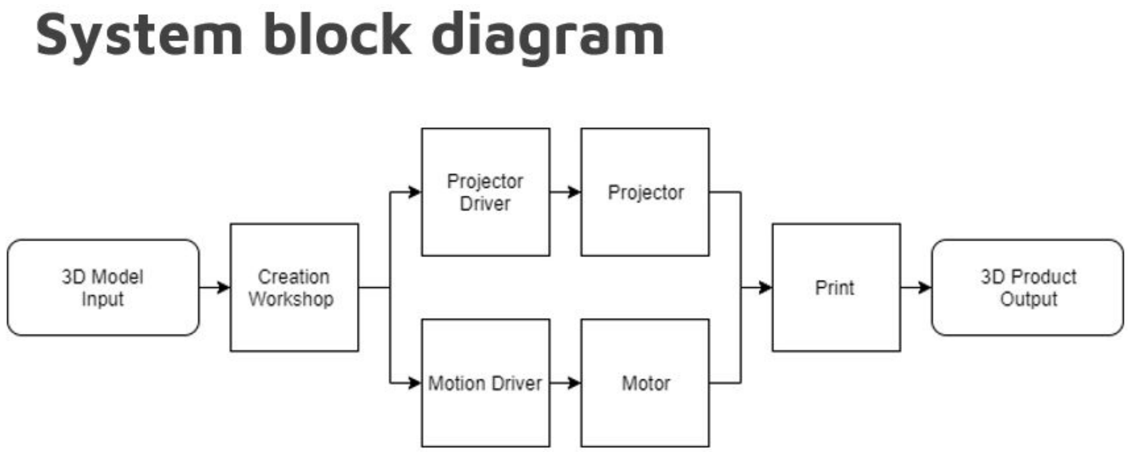
May. 2020	Final presentation and document about our product.



4.2 Feasibility Assessment

The realistic projection of our project is to create a three-dimensional object in our realistic world. We may not have the ability to implement our design ideally, this is because the property of our materials is not ideal, but at least we could print out a three-dimensional shape of what we want.

The State foreseen challenges of our project is to minimize our inaccurate printing.

4.3 Personnel Effort Requirements

Task#	Task details	Hours
1	Digital Micromirror Devices Array	Total: 126
1.1	Collect relevant materials	12
1.2	Design the prototype of DMD	15
1.3	Replace the UV light of projector	14
1.4	Revise and set up the driver of DMD	25
1.5	Test the pattern of UV source	10
1.6	Design a packing box for the projector by solid works	25
1.7	The open interface for DMD by GUI	20

1.8	Fixed projector on the table	5
2	X-Y-Z Motorized Stage	Total: 107
2.1	Collect relevant materials	12
2.2	Design the prototype of motorized stages	20
2.3	Set up the driver of the stage	30
2.4	Test and revise the driver by GUI	30
2.5	Connect the motorized stage to projector	10
2.6	Fixed motorized stage	5
3	Photolithography	Total: 97
3.1	Collect relevant materials	12
3.2	Decide chemical materials for Photoiniator and Photopolymer	20
3.3	Test the functions of Photoiniator	30
3.4	Test the functions of Photopolymer	30
3.5	Fixed on the printer	5
4	Final Test	30

4.4 Other Resource Requirements

Our project will need a Power supply for our new projector, a 385nm LED, DLP 3D printer GUI from TI, etc.

4.5 Financial Requirements

We may need our new projector covered by our clients.

5. Testing and Implementation

Testing is an **extremely** important component of most projects, whether it involves a circuit, a process, or a software library

Although the tooling is usually significantly different, the testing process is typically quite similar regardless of CprE, EE, or SE themed project:

1. Define the needed types of tests (unit testing for modules, integrity testing for interfaces, user-study for functional and non-functional requirements)
2. Define the individual items to be tested
3. Define, design, and develop the actual test cases
4. Determine the anticipated test results for each test case 5. Perform the actual tests
6. Evaluate the actual test results
7. Make the necessary changes to the product being tested 8. Perform any necessary retesting
9. Document the entire testing process and its results

Include Functional and Non-Functional Testing, Modeling and Simulations, challenges you've determined.

5.1 Interface Specifications

– Discuss any hardware/software interfacing that you are working on for testing your project

5.2 Hardware and software

– Indicate any hardware and/or software used in the testing phase

– Provide brief, simple introductions for each to explain the usefulness of each

5.3 Functional Testing

Examples include unit, integration, system, acceptance testing

5.4 Non-Functional Testing

Testing for performance, security, usability, compatibility

5.5 Process

– Explain how each method indicated in Section 2 was tested

– Flow diagram of the process if applicable (should be for most projects)

5.6 Results

– List and explain any and all results obtained so far during the testing phase

- – Include failures and successes
- – Explain what you learned and how you are planning to change it as you progress with your project
- – If you are including figures, please include captions and cite it in the text

• This part will likely need to be refined in your 492 semesters where the majority of the implementation and testing work will take place

-**Modeling and Simulation**: This could be logic analyzation, waveform outputs, block testing. The 3D model renders modeling graphs.

-List the **implementation of Issues and Challenges**.

6. Closing Material

6.1 Conclusion

Summarize the work you have done so far. Briefly, re-iterate your goals. Then, re-iterate the best plan of action (or solution) to achieving your goals and indicate why this surpasses all other possible solutions tested.

6.2 References

This will likely be different than in the project plan since these will be technical references versus related work/market survey references. Do professional citation style(ex. IEEE).

6.3 Appendices

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout, etc. PCB testing issues etc. Software bugs etc.