Strain visualization microsensor based on Moire fringes

DESIGN DOCUMENT

Team 9

Client: Dr.Long Que

Adviser: Dr.Long Que

Christian Tanberg: Project Manager

Parvaraj Bhatt: Design Engineer

Ki Jun Shin: Research Lead

Matthew Thies: Test Engineer

Team Email: sddec20-09@iastate.edu

Team Website:http://sddec20-09.sd.ece.iastate.edu/team.html

Revised: Feb 23/V1

Executive Summary

Development Standards & Practices Used

- Following all safety procedures
- Weekly meetings
- Document all processes

Summary of Requirements

- Measure the tensile and compressive strain
- Visible by the naked eye
- Use of Moire Fringes
- Create a strain visualization microsensor

Applicable Courses from Iowa State University Curriculum

- EE 224 and 324 - Signals and Systems I & II
- EE 531 - Micro and Nano Systems and Devices
- EE 532 - Microelectronics and Fabrication Techniques
- EE 538 - Optoelectronics Devices and Applications

New Skills/Knowledge acquired that was not taught in courses

Through the research and design of this project we have learned many new skills that we haven't yet covered in class. The first skill we learned was how to prototype new designs. We also learned how to work with a client to reach the desired outcome. Finally, we learned what moire fringes are and how they are used.

Table of Contents

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Introduction

1.1 Acknowledgement

Thank you to Dr. Long Que for his continued guidance throughout our project.

1.2 Problem and Project Statement

Due to the increased use of large structures, such as buildings and bridges, new ways of determining how much strain the structure is under needs to be developed and tested.

A possible solution for this problem could be the development of a strain visualization microsensor based on moire fringes. This would make it easier to determine the compressive and tensile strain of a structure.

The overall goal of this project is to design and prototype a microsensor that accomplish the task stated above.

1.3 Operational Environment

This product, when completed, will be used throughout various environments. It will need to withstand heat, cold, wind, dust and other forces of nature.

1.4 Requirements

Our project must measure the compressive and tensile strain of an object. We must be able to design and build our project within our budget of $500. Finally, our results have to be seen through the naked eye.

1.5 Intended Users and Uses

The intended user of our project is Dr. Long Que. The use of our project will help the user measure the compressive and tensile strain of a structure.

1.6 Assumptions and Limitations

Assumptions: Our microsensor will be able to measure the tensile and compressive strain of a structure with the use of moire fringes.

Limitations: Must be visible to the naked eye

1.7 Expected End Product and Deliverables

The end product will be a microsensor that measures the compressive and tensile strain based on moire fringes. The amount of strain that structure has must be visible to the naked eye.

2. Specifications and Analysis

2.1 Proposed Approach

In an article we read, they described a strain visualization sticker using moire fringe patterns. A microsensor takes in a nonelectrical quantity and converts into an electrical signal. Tensile and compressive strain would be such a quantity.

A microsensor would be attached to the structure that would keep track of the strain. The microsensor would send a signal if the strain goes over a certain level that could cause failure. There would be a moire fringes pattern on the structure that would show by numbers the level of strain. Levels of 1-5 or 1-10 would be visible without having to go near the actual structure.

2.2 Design Analysis

Our group is still in the research phase of the process. We have looked at several articles given to us by our advisor over how moire fringes are used to measure strain and how we might implement it with structures. We are currently brainstorming designs of how we can apply what we have learned.

2.3 Development Process

Our group is using the Agile development process. We are using this method to assign roles and jobs to each of our group members based on their strengths and weaknesses.

2.4 Conceptual Sketch

Currently our design process is in its beginning phase and as of now, our sketches are still in process.

3. Statement of Work

3.1 Previous Work And Literature

Include relevant background/literature review for the project

– If similar products exist in the market, describe what has already been done

– If you are following previous work, cite that and discuss the **advantages/shortcomings**

– Note that while you are not expected to "compete" with other existing products / research groups, you should be able to differentiate your project from what is available

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

3.2 Technology Considerations

Highlight the strengths, weakness, and trade-offs made in technology available.

Discuss possible solutions and design alternatives

3.3 Task Decomposition

In order to solve the problem at hand, it helps to decompose it into multiple tasks and to understand interdependence among tasks.

3.4 Possible Risks And Risk Management

Include any concerns or details that may slow or hinder your plan as it is now. These may include anything to do with costs, materials, equipment, knowledge of area, accuracy issues, etc.

3.5 Project Proposed Milestones and Evaluation Criteria

What are some key milestones in your proposed project? Consider developing task-wise milestones. What tests will your group perform to confirm it works?

3.6 Project Tracking Procedures

What will your group use to track progress throughout the course of this and next semester?

3.7 Expected Results and Validation

What is the desired outcome?

How will you confirm that your solutions work at a **High level**?

4. Project Timeline, Estimated Resources, and Challenges

4.1 Project Timeline

• A realistic, well-planned schedule is an essential component of every well-planned project

• Most scheduling errors occur as the result of either not properly identifying all of the necessary activities (tasks and/or subtasks) or not properly estimating the amount of effort required to correctly complete the activity

• A detailed schedule is needed as a part of the plan:

– Start with a Gantt chart showing the tasks (that you developed in 3.3) and associated subtasks versus the proposed project calendar. The Gantt chart shall be referenced and summarized in the text.

– Annotate the Gantt chart with when each project deliverable will be delivered

• Completely compatible with an Agile development cycle if that's your thing

How would you plan for the project to be completed in two semesters? Represent with appropriate charts and tables or other means.

Make sure to include at least a couple paragraphs discussing the timeline and why it is being proposed. Include details that distinguish between design details for present project version and later stages of project.

4.2 Feasibility Assessment

Realistic projection of what the project will be. State foreseen challenges of the project.

4.3 Personnel Effort Requirements

Include a detailed estimate in the form of a table accompanied by a textual reference and explanation. This estimate shall be done on a task-by-task basis and should be based on the

projected effort required to perform the task correctly and not just "X" hours per week for the number of weeks that the task is active

4.4 Other Resource Requirements

Identify the other resources aside from financial, such as parts and materials that are required to conduct the project.

4.5 Financial Requirements

If relevant, include the total financial resources required to conduct the project.

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 semester where the majority of the implementation and testing work will take place

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

-List the **implementation 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 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.