Strain visualization microsensor based on Moire fringes

DESIGN DOCUMENT

Team 9

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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

In our research of Moire Fringes we have found several examples of similar techniques of using Moire Fringes to test the strain on structures. One example our technical advisor Long Que gave us showed the research group using stickers with the Moire Fringe pattern that displayed different patterns when the structure experienced different amounts of strain. They then used a camera with a telescope lens connected to a computer to get a measurement of the strain. Our project differs from this because instead of using a camera with a telescope lens connected to a computer to read the data we plan to make the sticker visible to the naked eye. This would allow the user to either go out and record the strain or use a drone with a camera to record the strain on the object if the location is in a remote area.

3.2 Technology Considerations

The primary strengths of our project is the capability to see the strain with the naked eye. This will allow the user to determine the strain without any access to electrical equipment. This will make the process of finding the strain easier and less expensive than previous methods. Another advantage of our product is the ability to find the strain from a distance with a drone. This will help the user because if the structure is located in a remote or hard to reach location instead of having to find a way to reach the area they can fly a drone in and take a picture of the strain.

One possible weakness of our product is instead of a machine reading the strain the sticker will display a number that correlates to the amount strain on the structure. This will lead to a higher degree of error due to the visible numbers being an estimate rather than an exact number. One way we can limit this error is through adding symbols or smaller increments between numbers.

3.3 Task Decomposition

We have separated our project into two sections. Two people will be working with the microsensor and two other members will work with the Moire Fringes. The group working on the microsensor will need to determine how we test the moire fringe pattern and how we plan to implement the microsensor. The group that will work with the Moire Fringe pattern will need to design and build the filter. This will include picking how they want to display the strain as well as any redesigns that need to be made.

After figuring out how to solve those problems we will share with the other group in our team and confirm if the solution is suitable.

3.4 Possible Risks And Risk Management

There are several possible details that could potentially slow our progress. One of those is the recent outbreak break of COVID-19 which has caused our group to work from home. This will prevent us from meeting in person, which will hurt communication. We also will not be able to meet with our advisor, Dr. Long Que. This is a big hindrance as communication is slowed down and significantly more difficult. Another way it hurts our progress is that without access to labs we will be unable to build or test or project until next semester. One other detail that has slowed us down is the limited knowledge of the topic. Our group has never worked with Moire Fringes which has caused our group to spend a lot of time researching the topic so we can better understand what's going on.

3.5 Project Proposed Milestones and Evaluation Criteria

Some key milestones that we have achieved right now

- We brainstormed different ideas to build this project
- Met with Dr. Long Que to determine that we were going in the right direction
- Wrote the first version of the design document

Some key milestones we want to achieve by the end of the semester

- A plan on testing the sensor for next semester
- A final sketch or drawing for when we build it next semester

Possible testing method

- Build a small structure on which we would attach the microsensor to measure the levels of strain that the structure has upon it and see the changes with moire fringe patterns - structure could be a small bridge

3.6 Project Tracking Procedures

As of now we have been using a progress document with all the required tasks and when they are supposed to be finished by. This has helped us keep on track and to make sure everyone knows what they must complete by what time. Our group has decided to use this method for this semester as well as next semester to make sure we are all focused.

3.7 Expected Results and Validation

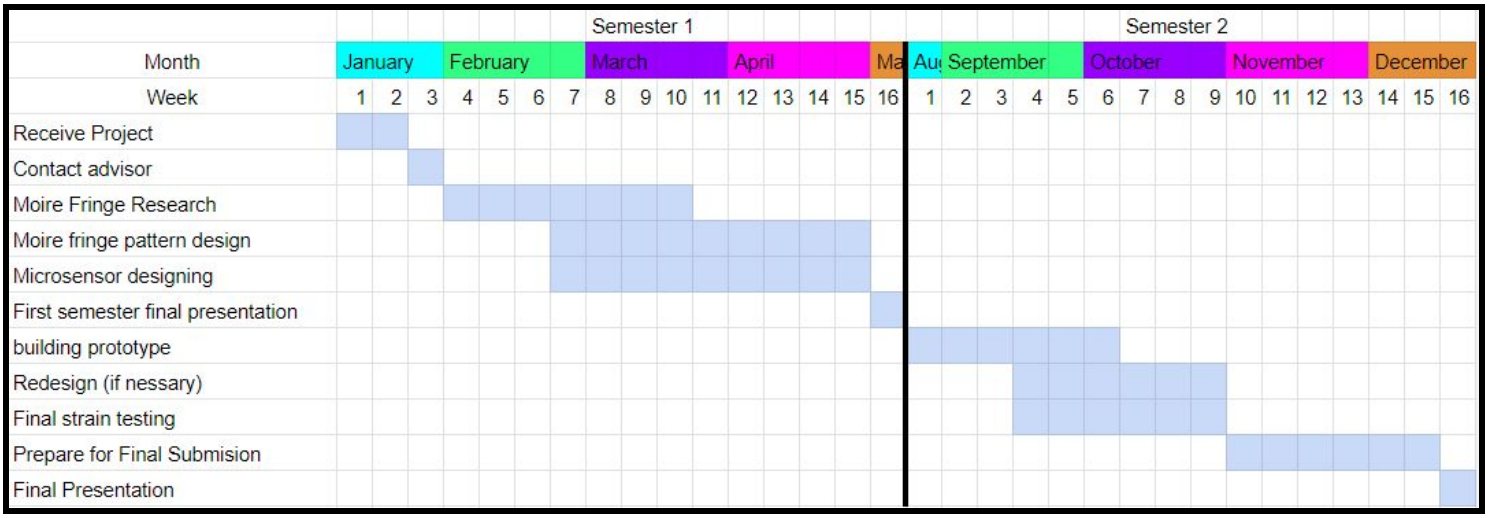
The desired outcome is to build a microsensor that will measure the compressive and tensile strain upon a structure and visualize it with a Moire Fringe pattern. It should be

visible to the naked eye. The pattern should have symbols or letters that would be easy to understand.

The desired outcome of this product is to create a Moire Fringe sticker capable of being observed with the naked eye. We will confirm the product works by adding a set amount of strain to a structure with a moire Fringe sticker to see if the sticker depicts the correct level of strain as the strain on the structure changes. If it accomplishes this task multiple times in a row it will show that this product can work consistently.

4. Project Timeline, Estimated Resources, and Challenges

4.1 Project Timeline



4.2 Feasibility Assessment

The project will likely be a Moire Fringe pattern attached to a structure. The pattern will be readable by our microsensor and will tell the amount of strain on the structure. A couple challenges we see in the future is finding a structure to test this on and getting the microsensor to be able to read the Moire Fringe pattern.

4.3 Personnel Effort Requirements

Task	Description	Estimated Hours
Moire Fringe Research	Researching moire fringe	30

	patterns and how they work Finding articles and videos to get a complete understanding How we can implement this in our project	
Microsensor Designing	Picking what sensor we want to use and how we will implement	20
Moire Fringe Designing	Picking a way to display strain on the sticker.	20
Building the moire fringe filter	Building the moire fringe filter for testing	40
Testing	Make sure the project is usable	30

4.4 Other Resource Requirements

We will need to build a structure to test the microsensor. We will be building the microsensor next semester alongside Dr. Que so we have yet to determine what materials we will exactly need.

4.5 Financial Requirements

As of now, our microsensor will be the only thing we need to use financial resources on. We have yet to determine how much it would exactly cost.

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.