Development of a Strain Visualization Microsensor based on Moiré Fringes

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Problem Statement

Due to the increased use of large structures, such as buildings and bridges, new ways of determining strain on these structures is needed. A possible solution for this problem could be the development of a strain visualization microsensor based on moiré fringes. This would make it easier to determine a level of strain on a structure.

What are Moiré Fringes?

A Moiré fringe is a pattern that is a result of overlaying two different patterns which creates a new image.

Solution

Our solution for this problem is to create a moiré fringe pattern consisting of two geometrical patterns that when superimposed will indicate the strain on a structure.

Requirements

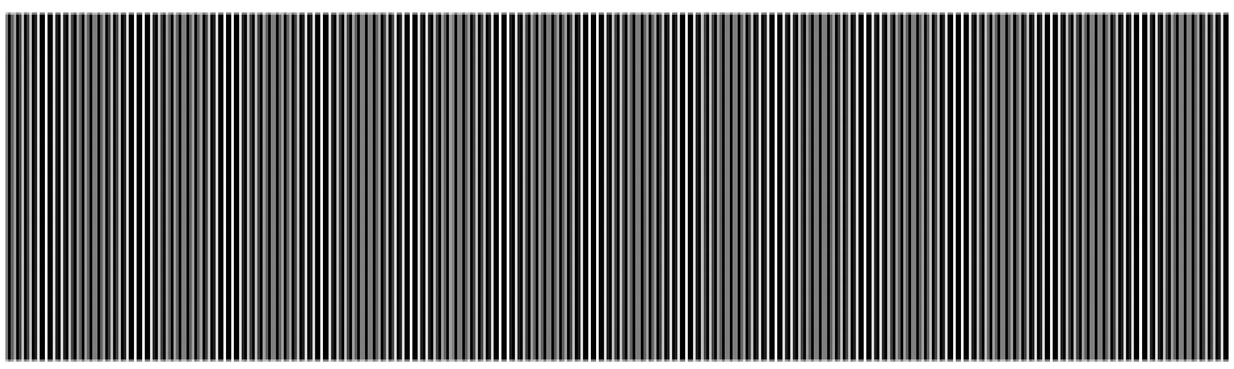
1. Visible to the naked eye
2. Two moiré fringe gratings - Number grating and line grating
3. Able to detect strain level
4. No electrical equipment
5. Withstand harsh forces of nature (heat, cold, wind etc.)

Design Approach

Number Grating

The image above is the grating (pattern) that will be on the bottom and attached to the structure. Therefore, it will be immovable.

Line Grating



The image above is the grating that will be on the top and will slide over the number grating. Therefore, as strain is applied to the structure the grating will move accordingly.

Technical Details

To perform the design and testing, we used MATLAB to build and simulate the moiré fringe patterns. This required us to do image processing to create the two gratings. We took two images (a number image and a blank white image) and plotted lines on them (white lines for the number image and black lines for the white image). We then added code to overlay the top (line) grating with the bottom (number) grating in order to make sure that the different levels of strain could be shown.

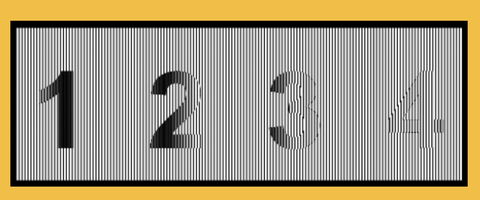
To create the lines, we used this formula

$$W = \frac{(p + \Delta p)}{\Delta p} * p \quad \text{p is the pitch (distance between lines + thickness of line)}$$

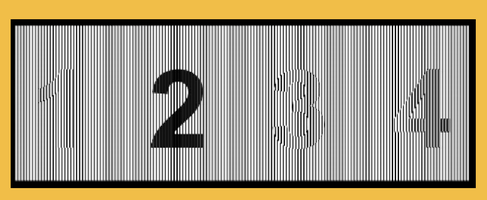
The pitch of the number grating is p and the pitch of the line grating is p + Δp. The value of Δp << p. W is the distance for the moiré fringe repeats. The value of W is usually significantly greater than p. We used length of the images as our W value. Our p value was 4.25 (distance of 3 and thickness of 1.25). With both those values we calculated p + Δp to be 4.3046 (distance around 3.05461 and thickness of 1.25).

Testing

To show different levels of strain, we had to simulate the top grating slide over the bottom grating. We inputted different values of p + Δp (distance changed slightly to be around 3.05461) to show each level highlighted. The images below show how it would look for each strain level. Level 1 representing normal state. Level 2 under some strain. Level 3 is danger strain. Level 4 is possible collapse/evacuation.

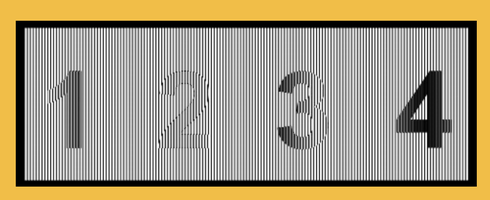


Level 1



Level 2

Level 3



Level 4

Intended Users

Our product would be used by anyone that requires a structure or object that needs strain to be measured. An example would be a local maintenance department for structures in their district.

Standards and Project Resources

Following all IEEE safety procedures
Weekly meetings
Bi-weekly reports
MATLAB