OPT211 Final Project Spring 2024

Far-Field Diffraction Simulator

Introduction:

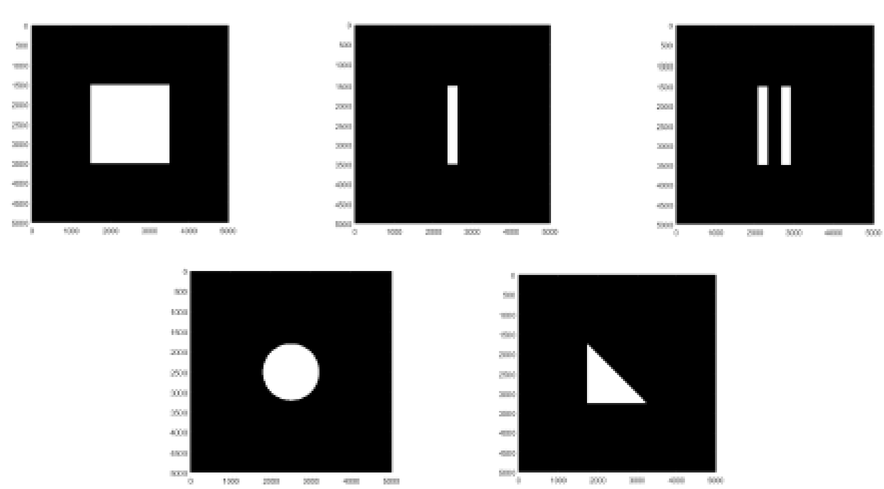
For your final project, your team will be developing a far-field diffraction simulator. This document gives a general outline of the project. You will receive additional documentation explaining the project in further detail as the project progresses, but for now, you should begin to develop your simulation program.

During the course of this project, Greg and the TAs (particularly your cohort TA) are your experts. Use them to your advantage and as a resource. They are required to answer all reasonable questions you have. The better the question, the better answer they can give. You will have the highest success meeting synchronously with them, so seek them out in zoom office hours, after class, during lab, or ask to set up a zoom meeting with them. The more questions you ask, the easier it will be for you to complete the project.

The project is divided into three parts which will be described here:

Part 1: Aperture Simulator

You will develop an aperture simulator. The aperture simulator should use Lab 5, Part 5 as a template. Use the same starting method and basic characteristics described there to create the desired apertures. Explicit instructions on what shape and size to use for each aperture will be included within the second technical memorandum (to be released later). You should start thinking about how to script in Matlab to create apertures similar to these:



Your team will be given a starting set of five apertures you must create in Matlab. Additionally, depending on the number of people on your team, you will propose three to four more apertures that your team will work out. Your cohort TA will approve your ideas or suggest more manageable ones. If you encounter minimal problems creating these apertures, we have many additional aperture ideas we would like you to try. Let us know, and we'll talk about it.

Part 2: Calculation of the Diffraction Pattern

From a mathematical standpoint we are going to keep the simulation simple. You are going to calculate the diffraction pattern using the following steps:

1- Compute the Fourier transform of the aperture function.
2- Properly center the Fourier transform.
3- Square the Fourier transform to calculate the intensity (ensuring you are including only real data).
4- Rescale the intensity magnitude so that the diffraction pattern will plot in a visually useful way.

You received and will receive more information on how this calculation actually works and some tips, tricks, and hints during lecture.

Part 3: Plot the Diffraction Pattern and Aperture Functions

You will be required to produce several plots for each aperture:

1- The aperture as an image
2- The full, far-field diffraction pattern
3- A smaller field view of the center of the diffraction pattern
4- 2D cross sections of the intensity in all directions exhibiting diffraction features

Technical memorandum one includes instructions on the specific requirements of these plots. Your group should start to think about how you will best be able to display all the requested data and how you may select the data for plotting from the existing calculations.

All of your plots must be presentation quality although some of the labeling formality will be simplified.

There is one tricky aspect to the plotting. You will need to rescale the color map to make the diffraction patterns display as you would see them in a laboratory setting. It is up to you to figure out how to do this or ask the right questions to get help beyond the relevant lectures.

You will be provided with "ideal" plots for the square aperture so you can see what your images should look like.

The Final Script:

One of the hardest parts of this project may turn out to be making the script for all three parts of this project work together harmoniously. You will need to define a final script which you will run to execute your program. Using user prompts or some other interface technique, the user will select an aperture from pre-determined aperture library and display all relevant plots and images for that aperture. This must all be done without generating any warnings or errors or causing the computer to crash.

You may utilize a single script or you may break each section of this project into separate functions which will be called by your master script when it is executed. The decision will be up to you.

The Final Interview and Report:

You will write an informal report describing your script and what it does. Following submission of this report, you will be required to meet on Zoom or in person with Greg and your cohort TA for a 10 to 15 minute group interview. We will run your script, discuss any problems with it, talk about how your group functioned and who worked on what, and you will have an opportunity to give me feedback on the course and the project.

The First Steps:

This is your project. In the end, your team should solve the problem in the best way you see fit and assign group roles to play to each team member's skills. Communicate regularly and help each other. If you have questions, ask the questions as a team, not as individuals.

If you feel overwhelmed and lost by all of this, sit back, take a deep breath, and start simply:

- ✓ Identify roles within your team. As an example:
    - ➢ Aperture Engineer
    - ➢ Plotting Guru
    - ➢ Team Leader, Science Officer, and Organizational Manager
- ✓ Come up with a team name (It may seem silly, but you should have pride in your team)
- ✓ Begin thinking about how the program will work. Create a flowchart or a text description of the project. A flowchart would be an excellent addition to your final report.
- ✓ Using the square aperture you already have as the starting point, calculate and plot its far-field diffraction pattern. Once this works, plot the relevant cross sections and begin adding more apertures.

Note: *Across the duration of the final project, you will be required to show weekly progress to your cohort TA during the labs or in an independent conversation with your group TA. This will count towards your final project grade! This is done to discourage last minute work on the final project.*