ESPI System Documentation

Introduction:

ESPI stands for Electronic Speckle Pattern Interferometry and is a method that can be used to visualize mode shapes of a vibrating object.

The ESPI system described below was designed by Thomas R. Moore.

If there are any questions about this documentation or the ESPI system in the CAML lab, Callie Valenzisi can be contacted at callievalenzisi@gmail.com or callie.valenzisi@mail.mcgill.ca

Equipment needed:

- Isolation table
- 13 ThorLab magnetic bases
- 1 cube beam splitter
- 1 plate beam splitter
- 4 small circular mirrors
- 1 polarizing lens
- 1 sheet of opal glass
- 1 laser
- 1 40x microscope
- 1 100x microscope
- 1 camera (a2A3840-45ucBAS used in CAML lab)
- 1 Camera lens
- Speaker
- Function Generator

Layout:

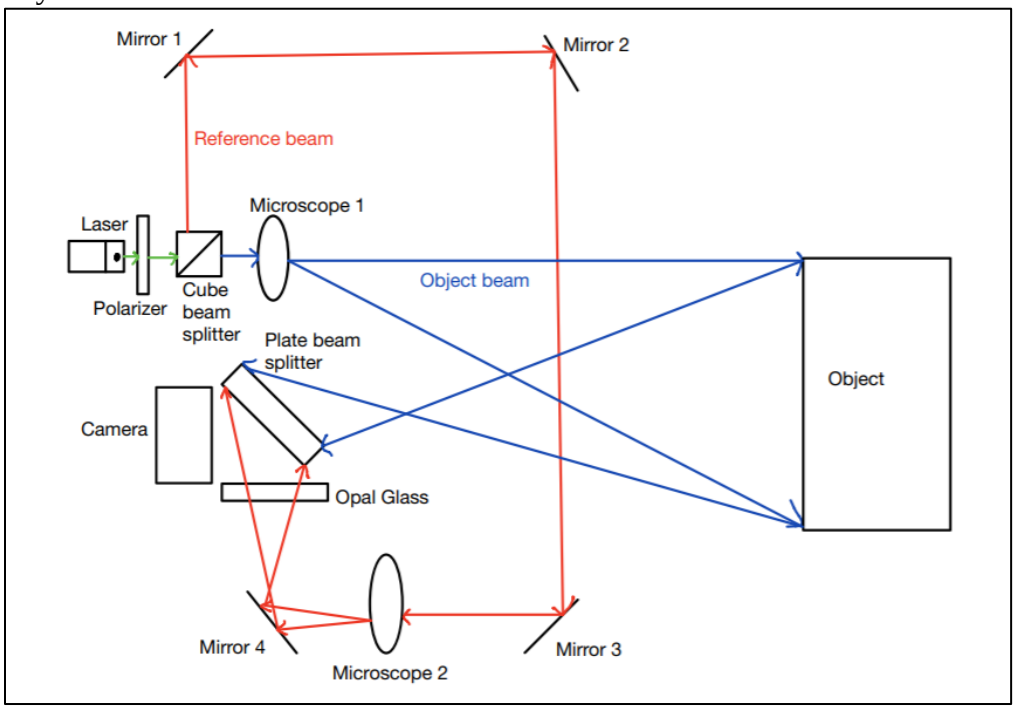

Figure 1

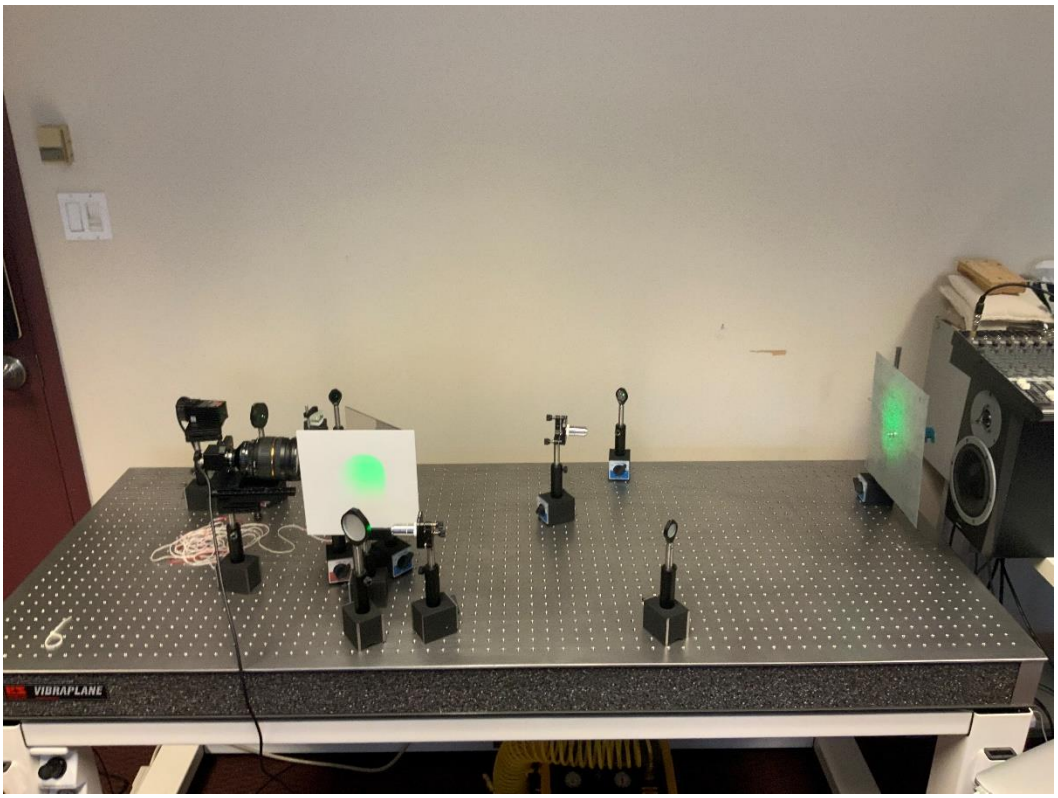

Figure 2

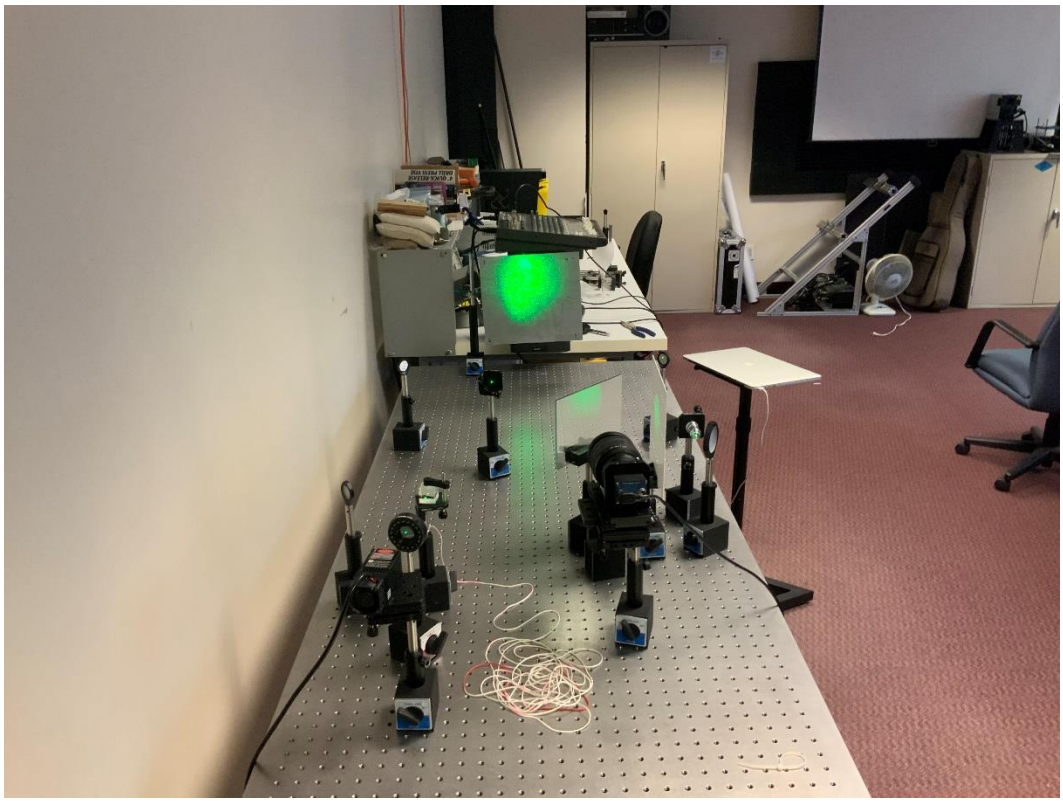

Figure 3

Figure 1 is a diagram of the setup. It is important to note that the diagram is not drawn exactly to scale, but it does provide a good starting point.

Figure 2 is a side view of the setup while the laser is on. The metal plate can be replaced by whatever object is being tested.

Figure 3 is the view from behind the laser and camera while the laser is on. Again, the metal plate can be replaced by whatever object is being tested.

Directions (for CAML lab):

1. Set up the equipment according to the layout shown above. The exact sizing is not crucial to the setup, but you need to ensure that the length of the reference beam path and the length of the object beam path are very close (within a few centimeters of each other). The best way to check this is to connect a string to the cube beam splitter (where the two separate paths begin) and calculate the length of one of the paths, mark it on the string, then compare that to the other path. Continue to adjust the layout until the paths are very close.
2. Turn on the laser. Adjust the mirrors and the microscopes (heights and angles, not position unless completely necessary and if so, re-adjust your setup so that the path lengths are close) so that the beams are reflecting properly (you should see a small spot in the color of the laser on the mirrors if the beam is properly reflected, shown in figure 4) and that the beams are going through the microscopes (you can test this by putting your hand in front of the microscope and if your hand is illuminated by the color of the laser then it is working correctly, shown in figure 5). Note: be very careful during this step, the laser is very strong and make sure it doesn't get near your eyes. If you have laser-protective goggles, they should be worn during this step.

Figure 4

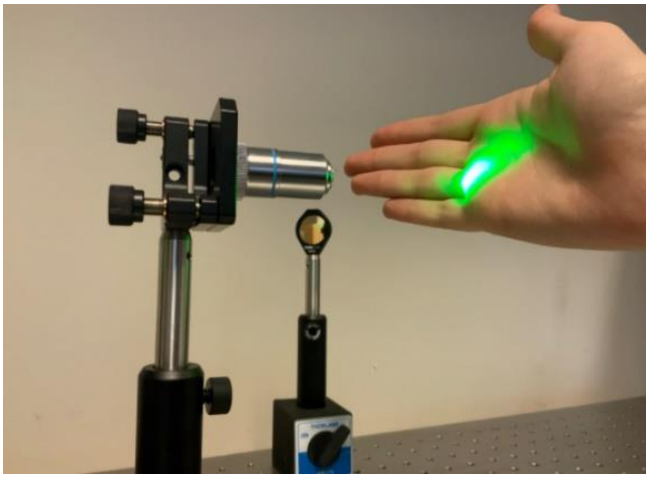

Figure 5

3. Now that the setup is working correctly, turn on the compression table. You should refer to the documentation for the compression table you are using to get more information about how to properly operate the table.
4. If you know the resonance frequency of the object you are testing, you can skip to step 5. Open Audacity and record a sample of you tapping the object you are testing, in the location you are testing. Then highlight that portion of the sample, choose analyze then spectrum plot. Hover your cursor over the peak of the graph and the frequency will appear below. That is your resonance frequency.
5. Using the function generator connected to a speaker, output a sine function at your resonance frequency.
6. Slowly increase the volume of the speaker until you start to see mode shapes on your image processing program (see instructions below). Note: you will not need a very large output from the speaker to see mode shapes, in fact be careful that you are not over-driving the object.

Notes:

The system is not perfect and adjustments will be needed for every object that is tested. I have listed below a few adjustments that can be made to the system that have been successful in optimizing the system for different objects. Note: some of these adjustments may help and some may make the system worse, so test each one independently.

- Move microscope 1. This does not affect the path length, so it can be moved forwards and backwards without the need for other adjustments. I have noticed that for a smaller object it is better to have the microscope closer to the object and for a larger object to have it closer to the beam splitter.
- Adjust the angle of microscope 1 and 2. There are two knobs on the microscope, one will move the beam up and down and the other will move the beam to the left or the right.
- Switch microscope 1 and 2. They have different magnifications and depending on the object having the 100x microscope illuminating the object may make the image clearer.
- Put a polarizer in front of the camera. This significantly helped with the speckle contrast when testing with the wine glass.
- Lightly tap the compression table to create some decorrelation.

Image Processing Program

The code can be accessed on GitHub.

The README file contains all instructions to get the program running, but for simplicity I have also included the instructions below.

Requirements

- Install pylon: https://www.baslerweb.com/en/products/software/basler-pylon-camera-software-suite/
- Install pypylon using the following command (pip info: https://pip.pypa.io/en/stable/): pip3 install pypylon
- Install opencv using the following command: pip install opencv-python (depending on the version of python installed you may need to use pip3 instead ofpip)
- Install Tkinter using the following command: pip install tk (depending on the version of python installed you may need to use pip3 instead of pip)

Installing

- Download the folder ESPIFINAL to your computer, make sure you note the path to this folder

Executing program

- Run the espifinal file in a terminal of your choice using the following command: python3 *path to the espifinal.py file* (ex: python3 C:\Users\calli\Documents\ESPIFINAL\espifinal.py)
- command for CAML Laptop (python C:\Users\Gary\Desktop\ESPIFINAL\espifinal.py)
- A window will appear with two options: consecutive differencing(in black and white), and consecutive differencing (in color) choose which one applies to you
- Then three different windows will appear. One is the consecutive differencing, one is a live view, and the other is control over the different parameters (these tabs are labeled)
- Click the esc key to terminate the program

Acknowledgments

- [Inspiration](https://github.com/drscotthawley/image-capture-opencv)
- [Tkinter Tutorial](https://www.python-course.eu/python_tkinter.php)
- [Single Capture Code] (https://github.com/basler/pypylon/blob/master/samples/opencv.py)