THE DEVELOPMENT OF A MATLAB PROGRAM TO EXTRAPOLATE A 3D SURFACE FROM A SET OF 2D, SHALLOW DEPTH OF FIELD, IMAGES

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OBJECTIVE:

1. Learn MATLAB
2. Create a program that will take in a macrophotography-style “stack” of images and return a 3D surface of the object pictured.

PURPOSE:

To determine the 3D structure of a target for SHERLOC and other instruments

The world is rarely flat
BACKGROUND: WHAT I HAD TO WORK OFF OF

- WHAT IS MACROPHOTOGRAPHY?
- AND HOW CAN I USE IT TO MY ADVANTAGE?

Source: http://www.cs.cornell.edu/~erenrich/dof/
IMPLICATION:
THE RELATIONSHIP BETWEEN FOCUS AND DISTANCE CAN BE RECOGNIZED BY A COMPUTER PROGRAM!
THE LAPLACIAN

\[ L[f(x, y)] = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \]

- The Laplacian is a common edge detection technique.
- Uses the second derivative, so is very sensitive to quick changes.
- Due to this, the Laplacian is very sensitive to being in focus or not.

Source: http://cis.cs.technion.ac.il/Done_Projects/Projects_done/VisionClasses/Vision/Edge_Detection/node5.html
PROOF OF CONCEPT:

- **The program applies a Laplacian mask as a focus-sensitive edge detection algorithm.**
- **Next, for each pixel, the highest value is found and used.**

Program then attempted to display all points (2048x1536x29)
NEED SOME WAY TO SLIM THE DATA...

- LOOKED AT DATA, THERE ARE IN GENERAL TWO TYPES OF SETS, NOISE AND SIGNAL
NOW HOW DO WE GET SMOOTHER DATA?

- **Averaging (Mean) Filter**: A simple way to reduce noise

Replaces the value of a pixel with the sum of those around it:

```
1/9  1/9  1/9
```

- **The Averaging Filter really brings out the data**
HOW TO GET INTER-FRAME DATA POINTS

- Remember that naïve assumption earlier?

...But there was a problem...

Averaging Filter

Laplacian Mask

Parabolic Fit

Interpolate and Display
The parabola sometimes doesn’t fit right...
BECAUSE THE DATA IS GAUSSIAN, NOT PARABOLIC!
SO WE ARE ON THE RIGHT TRACK

The Median Filters replaced the Averaging Filters

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Neighbourhood values:
115, 119, 120, 123, 124
125, 126, 127, 150

Median value: 124

Gaussian fits replaced Parabolic fits

- Though this cause the program to take a lot longer to run

A Better Interpolation function was added, using a natural neighbor method instead of linear interpolation
A rudimentary macrophotography strategy is to simply make a composite of every “in-focus” image.
The End