Project Proposal
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EE367

Fourier Domain Denoising in Light Field Moment Imaging (LMI) Algorithm

Motivation

The imaging and presentation of depth in 3-dimensional structures has historically proven difficult in the semiconductor industry without the use of relatively expensive equipment. Defects such as solder splash and balling, incorrect wire bond geometries, and lifting of traces on substrates are difficult to view and understand with a typical 2-dimensional microscope photo. One method, developed by researchers at Harvard University in 2013, provides the ability to view simulated depth and perspective using only two source images taken at two different focal distances. The algorithm, known as LMI, is an effective means to produce animated photos of micro- and macroscopic objects, giving the viewer the effect of 3D without the expensive equipment necessary to implement real 3D technology. Unfortunately, the method is still in its infancy, specifically with regard to the development of the mathematical background and image improvement methods. The lack of denoising in the algorithm results in severe color cast and artifacting as low frequency noise in the Fourier domain is amplified and converted back to the spatial domain, rendering the final photos inaccurate.

Related Work

Current denoising algorithms are numerous and varied in their intended applications. As we've learned in class, basic Gaussian and bilateral filtering mechanisms are effective for general white noise, but learning to balance an algorithm with the inevitable loss of detail is a challenge. This is especially critical in a project such as this where the majority of the image resides at a lower spatial frequency. The main paper hypothesizes two different methods for noise reduction [2,3] that may prove effective alone or in combination with more traditional noise reduction methods such as Gaussian or Butterworth low-pass filters. Much of this is dependent on the nature of the noise, which will not become evident until the LMI script is developed, a task that has already proven difficult.

Project Overview

The goal of this project is two-fold: to develop the LMI algorithm into a MATLAB script and to implement several noise reduction algorithms in order to analyze their efficacy on the LMI images. In order to determine which noise reduction methods will be most effective, the LMI script must be developed and the images analyzed in the Fourier domain, something not provided by the author of the original paper. Development of the script has already proven difficult during a cursory attempt, mainly due to a lack of units and detail in some areas such as the development of the spatial frequency matrix.

Milestones, Timeline, and Goals

Approval of report – 20 February: Development of LMI algorithm, analysis of noise. *Result:* functioning MATLAB script, noise characterization.
21 February – 28 February: Implementation of denoising algorithms. *Result:* multiple denoising algorithms implemented in MATLAB, quantitative data on efficacy.
1 March – 6 March: Experimentation with range of image types, specifically centered around microscopy applications. *Result:* several photos with LMI and denoising applied, along with

quantitative data for each.
7 March – Due date: Write report, wrap up any loose ends. *Result:* completed report.

References

[1] A. Orth and K. B. Crozier, "Light field moment imaging," *Optics Letters*, vol. 38, no. 15, p. 2666, Jul. 2013.
[2] L. Waller, L. Tian, and G. Barbastathis, Opt. Express 18,12552 (2010).
[3] D. Paganin, D. Barty, P. J. McMahon, and K. A. Nugent, J. Microsc. 214, 51 (2004).