Project Name: Machine Learning Methods for Demosaicing and Super-Resolution
Members: Yu-Sheng Chen, Stephanie Sanchez

Motivation:
Demosaicing is a well known long-standing method. This project presents a new approach to the demosaicing method using machine learning techniques.

Related Work:

For the traditional methods of demosaicing we mentioned the low-pass-filtered chrominance method in the lecture. We can use Gaussian filter or bilateral filter [1] as our low-pass filter. Another approach is edge-directed interpolation, which is proposed by Gunturk et al [2], it tries to interpolate the image based on the direction of edges, to preserve the edge sharpness. We also explored the linear interpolation method proposed by Malvar et al [3], it uses only linear kernels to perform the demosaicing by optimizing the kernel gain parameters on Kodak photo dataset.

There are many machine learning methods for image super-resolution[4], for example, k-Nearest Neighbors, Support Vector Regression and Super-Resolution Convolutional Neural Network. Machine learning techniques are used to predict the missing color/texture information. In the general image optimization problem, we model the problem as an optimization problem[5][6]. As mentioned in [5], image optimization problems contain (1) a variable which represents the target image to be reconstructed, (2) a linear operation matrix which represents the downsampling/demosaicing process, (3) a penalty measure which represents the difference of the results of downsampling/demosaicing from the measured data, and (4) the priors and constraints on the the variables. Usually we encode the prior information as a penalty (regularization) term in the objective function, to manage the ill-conditionedness of the original reconstruction problem. Once we define the constrained optimization problem, iterative update methods are applied to solve the best estimate of the higher resolution image.

Overview:

If we consider demosaicing and super-resolution together we notice that both methods utilize a technique to fill in pixel value information. Demosaicing employs interpolation of nearby pixels to approximate the correctness of green, red, or blue values in a pixel [2]. One approach for super-resolution is to solve a least squares problem to generate high-resolution pixels from low-resolution images.

Due to the similarity between super-resolution and demosaicing, we will formulate an implementation of machine learning combined with super-resolution to achieve demosaicing's objective. There are various ways to compare our implementation of demosaicing to traditional methods. This includes PSNR or develop a technique to numerically measure artifacts generated from original methods and our implementation (or visually analyze artifacts).

For machine learning approaches, we will discuss the overfitting/underfitting occurrences to ensure optimal performance for each model (optimize hyperparameters). To generate the training data set, we will allocate labeled image data from ImageNet. This serves as our training output and we can downsample the images to become a bayer-patterned image as our training input for our model. This enables a large dataset for the majority of machine learning models.

If time permits, we will also investigate dual-cam applications with our model. That is, given a pair of images from a dual-camera system, we can determine the geometric mapping between pixels of both images. This allows us to either produce a larger image or lower the image artifacts.

Milestones/Goals:

Step1. survey state-of-the-art papers (even for other applications), choose some models to implement for the final comparisons.

Step2. Implement and verify our proposed model.

Step3. Compare with traditional methods, and consider to improve/reselect the model.

Step4. (if time permitting) Advanced dual-cam application: solve geometry matching between 2 cameras, then apply our proposed demosaicing/super-resolution.

Reference:

[1] Image-based modeling and photo editing, Oh et al., ACM SIGGRAPH 2001

[2] Demosaicking: Color Filter Array Interpolation, Bahadir K. Gunturk, 2014

[3] High-Quality Linear Interpolation for Demosaicing of Bayer-patterned color images, Henrique S. Malvar et al, ICASSP 2004

[4] Example-Based Image Super-Resolution Techniques, Mark Sabini and Gili Rusak, CS229 course project 2016

[5] Image Interpolation by Super-Resolution, Alexey Lukin et al, International Conference Graphicon 2006

[6] ProxImaL: Efficient Image Optimization using Proximal Algorithms, Felix Heide et al, ACM SIGGRAPH 2016