# One Shot High Dynamic Range Photography Based on Coded Shutter

EE 367 Project Proposal

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## 1 Motivation

High-dynamic-range (HDR) is a technique used in imaging and photography to reproduce a greater dynamic range of luminosity than is possible with standard digital imaging or photographic techniques. HDR images can represent a greater range of luminance levels than can be achieved using more "traditional" methods, such as many real-world scenes containing very bright, direct sunlight to extreme shade, or very faint nebulae. However, conventional HDR method requires multiple shot to generate the HDR image, which can be EXTREMELY time consuming when setting long exposure time. Besides, it suffers from ghosting artifacts and misalignments. In this work we proposed to use coded shutter that grided the scene of camera shot to adjust the exposure time of different region separately. Such method enables us to achieve HDR with at most two shots.

## 2 Related Work

### 2.1 Liquid Crystal Display

Programmable liquid crystal display(LCD) has been widely used to enhance image acquisition such as multiplexing light field acquisition and pattern selection for defocus deblurring([1] and [2]). By using such LCD, we can control the quantity of light goes through the camera shot.

### 2.2 High Dynamic Range

As illustrated in the motivation section, HDR often requires multiple shots to synthetize a high dynamic range image ([3] and [4]). The shortcoming is the current HDR technic are time consuming.

There exists some works pursuing one shot HDR photography. However, initial works like [5] use a monochromatic LCD display and a simple cutoff algorithm, leaving a lot of room for improvement.

## 3 Project Overview

Our project plans to use a LCD mask as a programmable shutter to tune the amount of light of different areas by adjusting exposure time of each area. Transmission of LCD has two different states, low transmission and high transmission (on/off). Ideally, on state is 100% transparent while off state is completely opaque. When the LCD mask is mounted in front of lens or CMOS, we are able to code exposure time for different areas according to spot metering. The whole project has both hardware part and software part.

### 3.1 Hardware

The DSLR we are going to use in this project is Nikon D750. This DSLR is able to connect to the computer and transfer images in real time. We need to find a proper LCD that is able to be mounted in front of lens or CMOS and controlled by the computer. The software will be run on the computer. The computer receives metering results from the camera, then calculates the exposure time of areas and passes to LCD.

### 3.2 Software

Given the result of metering, our software aims to calculate the optimal patterns of LCD mask. Similar to tone mapping, we need a coded shutter to fit high dynamic range objects into luminance range of 8-bits sensor, while preserving objects details and color. This could be regarded as an optimization problem and solved by gradient descent method. We will firstly treat LCD as ideal device and then tune the parameters by real data to achieve better results.

Alternative Solution: If we are able to find a grayscale LCD whose value is not only 0/1 but changes between 0 to 1, we dont need to code exposure time but just code transmission of different areas.

## 4 Milestones, Timeline and Goals

There are about 5 weeks for the project. In the first two weeks, we plan to find a LCD (either grayscale or monochromatic) as well as figure out how to control the LCD from the computer and transmit view from the camera to the computer in realtime. In the following two weeks, we are going to design and implement the software part, including prototypes and a working setup. In the last week, we will continue to refine the project and summarize it to a poster and a report.

The baseline goal of our project is [5], on the basis of which we aim to achieve pixel-level realtime LCD mask. Ideally, we want to win traditional HDR algorithms and even develop some future applications, such as HDR video or cameras with HDR mask on CMOS.

## References


[1] Hajime Nagahara and Rin-ichiro Taniguchi. Computational Photography Using Programmable Aperture, 2015.

[2] Hajime Nagahara, Changyin Zhou, Takuya Watanabe, Hiroshi Ishiguro, and Shree K Nayar. Programmable Aperture Camera Using LCoS. *ECCV*, 2010.

[3] Paul E. Debevec and Jitendra Malik. Recovering high dynamic range radiance maps from photographs. 2008.

[4] Frédo Durand and Julie Dorsey. Fast bilateral filtering for the display of high-dynamic-range images. *SIGGRAPH*, 2002.

[5] Cheng-Han Wu, Po-Nan Li, and Gordon Wetzstein. Mountable Dynamic Range Enhancer for Digital Cameras.