

# Implementation of a tone mapping operator for scotopic viewing conditions

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## Introduction

Creating night-time images and movies that look plausible has been a problem in the industry since the creation of camera. To capture an image we need enough light to create a measurable quantity on a camera sensor. For this reason, shooting at night was not possible until sensors sensitive enough were developed and even then the captured images do not look realistic. Movie industry circumvent these issues by manually color correcting the footage in post-production. We implement an algorithm presented in a 2011 SIGGRAPH paper capable of solving this problem in a psycho-physically plausible and consistent way for spectral images and also augment it by a technique taken from a paper in INRIA.

## Goals

The goal of the thesis is to implement a psycho-physically plausible tone mapping operator for low light spectral images and use it in an existing spectral renderer. Additionally, we would like to simulate loss of spatial resolution in scotopic conditions.

## Terminology

Colored vision starts its journey in rods and cones. These are cellular structures residing at the back of a human eye capable of detecting light. Human eye is an extraordinary piece of biological machinery with its very high dynamic range. We can divide it into two modes of vision:

- photopic vision - daylight, cones are mostly active
- scotopic vision - very little light, rods are mostly active

## Algorithm

The idea is to take the opponency model, which describes the visual information processing from cones, and extend it with influence of rod signals. We use the scotopic model to obtain the opponency values. These values are then fed into reversed photopic model to get a photopic response perceptually similar to scotopic viewing conditions. For acuity loss simulation in dark environments we use a bilateral filter, which smooths out any detailed features of an image but still preserves the edges. This idea was inspired by the INRIA paper on similar topic.

## Implementation

The algorithm described above was implemented in ART. Advanced Rendering Toolkit (ART) is a spectral rendering system with aim on modularity rather than speed which makes it a good choice for academic research and experimentation. What makes it special is that it is capable of handling spectral information along each step in the pipeline. We extended the `tonemap` part of ART. We added `--scotopic` option that selects the use of above algorithm when converting a spectral image. This option replaces the default `ArTRAW` converter with our custom one followed by a bilateral filter in the action sequence.

## Results



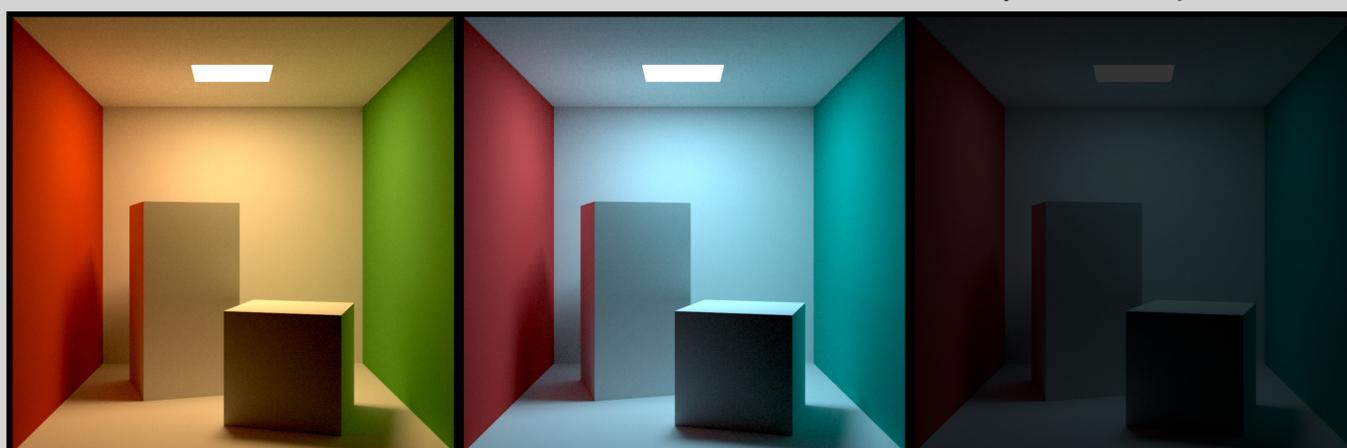
*photopic*

*scotopic*

*scotopic  
&  
adjusted exposure*



*photopic*



*scotopic & bilateral*