Comparative Analysis of Inverse Halftoning Techniques
Hana Darling-Wolf, Jeffrey Qiu
University of Toronto

Motivation

- **Halftoning** (or dithering): image compression technique which reproduces tone with a limited colour palette (e.g. black and white) using distribution of halftone dots.
- **Inverse halftoning**: retrieval of continuous-tone images from halftoned images.
- **Applications**: recovery and preservation of printed media [3], image editing [3], use of dithered images for lower bandwidth websites [1]
- **Problem**: Inverse processes can be energy intensive.
- **Goal**: evaluate techniques for inverse halftoning based on a standard of quality that considers both reconstructed image quality and computational efficiency.

Related Work

Many methods for inverse halftoning [3, 4, 6]:

- **Low-pass filter**: simplest, but causes edge information to be lost [3].
- **Look-up-table (LUT)**: improved both reconstruction accuracy and efficiency in comparison to previous implementations [3].
- **Edge-preserving denoising techniques** (e.g. bilateral).

Methods

- We used Floyd-Steinberg dithering to generate image sets with (i) 2-tone, (ii) 4-tone, and (iii) 16-tone colour palettes [5, 6].
- 200 training images, 100 test images from BSDS300 dataset [2].
- Implemented 6 inverse halftoning techniques:
  - (1) a low-pass filter*
  - (2) bilateral filter*
  - (3) Alternating Direction Method of Multipliers (ADMM) with Total Variation (TV)*
  - (4) ADMM with a denoising convolutional neural network (DnCNN)*
  - (5) Mese and Vaidyanathan’s LUT [3]
  - (6) A new technique called deep learning [8].
- Evaluated techniques based on average peak signal-to-noise ratio (PSNR), Structural Similarity Index (SSIM), and runtime per image.

* For techniques 1, 2, 3, 4, we conducted a hyperparameter search, and used the parameters which gave the highest average PSNR / SSIM.

Experimental Results

Reconstructed Image Quality vs. Runtime

Reconstructed Image Quality vs. Dithered Image Compression Level

References