EE367: Computational Imaging and Display
Final Project Proposal: Dehazing Remote Sensing Images
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1 Overview and Motivation

Remote sensing and satellite imagery are important tools in monitoring climate, agriculture, forestry, and human activity. A large challenge in gathering quality satellite images is the effect of haze. Haze, caused by cloud cover, pollution, or other atmospheric particles, degrades the image quality. For more visually pleasing and informative remote sensing images, dehazing is an important step in processing remote sensing images.

In this project, we are interested in exploring dehazing algorithms. Specifically, we plan to compare three different types of dehazing algorithms: physical-model-based with dark channel prior, non-physical-model-based with the DWT, and deep learning-based on the *SateHaze1k* dataset provided by Huang et al.

2 Related work

There are a host of existing dehazing algorithms, as well as dehazing algorithms specifically designed for remote sensing images.

These algorithms come in two main flavors: those based off physical models of light scattering due to atmospheric particles and those based off pure image processing techniques. In the non-physical models, the main goal in dehazing is to focus on the contrast ratio and details of an image, without consideration of the physical system.

These non-physical-model-based algorithms include the one proposed by Wang and Zhu, which employs the Discrete Wavelet Transform to properly weight each pixel in the image to enhance boundary shapes and dehaze.

Examples of algorithms related to physical models are based off the simple model:

$$I(x) = J(x)t(x) + (1 - t(x))A$$

where I is the hazy image, J is called the 'scene radiance' and in practice is the dehazed image, t is the light transmitted to the camera that is not scattered, and A is the global atmospheric light. These physical-model-based algorithms try to recover J from the input image I and estimations of t and A.

For example, Long et al. proposed a dehazing algorithm for single remote sensing images that estimated A to be constant. This is considered to be a good estimation for a remote sensing image, since these images are taken from far above the earth and A refers to the global atmospheric light. Long et al. also describe

$$t(x) = e^{-\beta(x)}$$

where β is the transmission attenuation caused by atmospheric scattering and absorption.

Long et al. refer to the paper by He et al., which uses a dark channel prior (an assumption that in natural images, at least one channel of each pixel is very dark). He et al. use this dark channel prior to estimate t and A for hazy but not remote sensing images.

Other models, such as the one proposed by Huang et al., employs deep learning for satellite image dehazing. Huang et al., also curated the hazy satellite image dataset called *SateHaze1k* which is available for download. In their paper, Huang et al. use a generative adversarial network that trains on the *SateHaze1k* dataset with both hazy and ground truth images.

3 Goals

3.1 Final goals

The main goal of this project is to compare results from 3 different types of algorithms (something similar to Wang and Zhu, something similar to Long et al., and something similar to Huang et al.).

We also want to:

1. Experiment with different loss functions in the GAN designed by Huang et al.
2. Provide both quantitative (PNSR, RMSE) and qualitative (visual appeal, image color) comparisons between these methods.

3.2 Intermediate goals

1. Do a more thorough literature review to more deeply understand how each algorithm is implemented.
2. Implement the physical and non-physical-based dehazing algorithms locally.
3. Figure out how to set up some cloud computing to train a GAN (and see if we can do transfer learning based off Huang et al.'s model).

4 Timeline

Week	Goals
Week 6	More in depth literature review, start implementing wavelet-based method
Week 7	Finish wavelet-based implementation and start implementing dark channel prior method
Week 8	Finish implementing dark channel prior method and do research into computing resources
Week 9	Set up computing resources and train GAN
Week 10	Final passes over code and paper writing

5 Other Notes and Thoughts

In doing initial research and reading, I also saw quite a few articles on deblurring satellite images. If I have time, I would also be interested in exploring this topic more (and perhaps creating a whole pipeline to handle processing remote sensing images, that includes both deblurring and dehazing steps). Also, if the teaching team thinks that focusing on deblurring would be a more interesting project, I would be happy to pivot!

6 References

1. Single Image Haze Removal Using Dark Channel Prior

   `http://kaiminghe.com/publications/cvpr09.pdf`

2. Single Remote Sensing Image Dehazing

   `http://levir.buaa.edu.cn/publications/SingleRemoteSensingImageDehazing.pdf`

3. Unmanned Aerial Vehicle remote sensing image dehazing via global parameters:

   `https://ieeexplore-ieee-org.stanford.idm.oclc.org/document/9194852`

4. Quality Evaluation of Image Dehazing Methods Using Synthetic Hazy Images:

   https://ieeexplore-ieee-org.stanford.idm.oclc.org/document/8654007

5. Remote Sensing Image Haze Removal Using Gamma-Correction-Based Dehazing Model:

   https://ieeexplore.ieee.org/document/8588980

6. Single Satellite Optical Imagery Dehazing using SAR Image Prior Based on conditional Generative Adversarial Networks

   https://openaccess.thecvf.com/content_WACV_2020/papers/Huang_Single_Satellite_Optical_Imagery_Dehazing_using_SAR_Image_Prior_Based_WACV_2020_paper.pdf

7. Adaptive Dehaze Method for Aerial Image Processing http://futuremedia.szu.edu.cn/assets/files/Adaptive%20Dehaze%20Method%20for%20Aerialimage%20processing.pdf

8. Domain-Aware Unsupervised Hyperspectral Reconstruction for Aerial Image Dehazing

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