

Motivation

There are a wide range of computational imaging systems that illuminate the object of interest by coherent light. Examples of such imaging systems are synthetic aperture radar (SAR) and digital holography. These systems all suffer from a very particular type of noise referred to as speckle noise. Speckle noise is very different and than typical additive noise, since it is multiplicative. Most solutions to tackle speckle noise seem to be heuristic. The main motivation for this work is the recent paper by Prof. Jalali and her collaborators that looks into such systems from a theoretical perspective and shows that compressed sensing in the presence of speckle noise is possible. However, the results of that paper are mainly theoretical. In this project, we are interested in taking advantage of powerful tools from machine learning, such as auto encoders, to implement algorithms that recover a signal in the presence of speckle noise.

Concepts

The problem of signal recovery from noisy samples that are corrupted by speckle noise is inherently very complex mathematically. To be successful in this project, I need to understand those concepts and then, based on the results of that paper and other prior work on application of compressed sensing, implement a proper recovery algorithm.

Connection to ECE

Computational imaging is very important to ECE in general, but mainly to Computer Engineering. It is a vital tool to understand the world around us and improve new technologies. Imaging is very important to the future of our world, especially in self-driving cars and modern medical sciences. I am very interested in working in this field in the future and think that this project will help my skills to get me there. Also, I will audit Prof. Jalali's course Topics in ECE: Application of ML and Statistics, which is on various modern computational imaging systems, such those I will study in this research. Hence, there is a direct connection between the work I am doing to a technical course taught in our department.

Also, I believe that research is an essential part of engineering. It is important that any engineer has experience in research and analytical thinking, since any job in the future requires thinking skills like this - whether it is working in industry such as software/hardware engineering or something more business related. I would learn a lot from this and these skills will follow me to future endeavors.

End Goal

The end goal of this project is to create an algorithm for speckle denoising or more generally recovery in the presence of speckle noise. I want to reach this goal by splitting it into smaller parts and working on each of them. My first step is going to be training proper autoencoders for signals we are interested in, such as images seen in SAR imaging of earth.

Getting to the goal would include a lot of coding, math, and thinking.

Most of my coding will be done in Python3 and the main libraries that I will be using are Numpy, Numba, and PyTorch. Numba is going to be used for a wide variety of operations such as speeding up calculations and will translate the code to be easily-compilable. Numpy is the basic mathematical calculation library that I will be using to work with doing operations on vectors. PyTorch is the biggest library that I will use since it is the main machine learning tool that I have. I'll be using that to train and use neural networks that I have to make. Also, PyTorch is an important skill to learn as an ECE undergraduate because of its wide use and doing this project would help me.

Learning all of these and understanding how they work will help me learn a lot, and will teach me a variety of things. First of all, I will mainly learn about image processing and machine learning, both of which are very important skills in today's world. I also think that I will learn a lot of coding, especially in python. This is a very important thing because coding is very essential to know now, especially where python is being used virtually everywhere.