

Title Page  
Approval Page  
Acknowledgements  
Table of Contents  
List of Tables  
List of Figures  
List of Symbols  
Summary

## **1 Introduction**

### **1.1 Dictionaries and Dictionary Learning**

Dictionaries are great! Just look at all the wonderful applications! Distinguish sparse coding and dictionary learning.

#### **1.1.1 Convolutional Dictionaries**

Define and explore the merits of convolutional dictionaries for signals with spatially or temporally invariant properties.

### **1.2 Convolutional Neural Networks**

So many successful convolutional neural networks over past decade!

### **1.3 Multi-Layer Dictionaries**

Reference Elad research tying convolutional neural networks to dictionary learning. Mention Zeiler, ect. Define multi-layer dictionary. Describe needs of multi-layer dictionary (specifically the need to be able to handle multi-channel signals).

### **1.4 Layout of rest of dissertation**

Be sure to highlight novel contributions!

## **2 Learning Dictionaries for Multi-Channel Signals**

### **2.1 Introduction**

Explain the problem and its connection to the rest of dissertation. Focus on the CSC problem.

## **2.2 Dictionary Types**

Explain the types of dictionaries for multi-channel signals and explain why I am focusing on multi-channel dictionaries (as opposed to single-channel dictionaries or some of the tensor-based approaches).

## **2.3 Literature Review**

### **2.3.1 CSC**

FISTA, ADMM, Chodosh and Lucey 2020, Wholberg comparisons

### **2.3.2 Multi-Channel Variants**

Why not ADMM? FISTA, Consensus ADMM, tight-frame assumption trick

## **2.4 My Novel ADMM Variant**

Low-rank approximation, problem substitution for stronger constraint (simplifying problem), the normalization trick

## **2.5 Conclusion**

Be sure to mention drawback of fixed  $\rho$

# **3 Learning Multi-Layer Dictionaries**

## **3.1 Introduction**

Explain model, where it would be useful, and the corresponding problems to solve.

## **3.2 Literature Review**

Zeiler 2010, Elad nature of neural networks, Carin probabilistic pruning networks, Murdock and Lucey, Chodosh and Lucey, (Might also want to dig into multi-layer ISTA and LISTA, ect.) I expect some redundancy between this section and some material in the introductory chapter, though this section should go into more depth.

## **3.3 My Novel Approach**

## **3.4 Conclusion**

I'm not sure if this chapter will need a conclusion or not.

## 4 JPEG Artifact Removal

### 4.1 Introduction

### 4.2 JPEG Algorithm

### 4.3 Literature Review

### 4.4 My Model

### 4.5 Handling Quantization

### 4.6 Experiments

#### 4.6.1 Experiment Setup

#### 4.6.2 Results

### 4.7 Conclusion

## 5 Non-Rigid Structure From Motion

### 5.1 Introduction

### 5.2 Literature Review

#### 5.2.1 Model

### 5.3 Low-Rank Approximation, Constraints, and Derivations

### 5.4 Experiments

#### 5.4.1 Experiment Setup

#### 5.4.2 Results

### 5.5 Conclusion

## 6 Practical Considerations

### 6.1 Boundary Handling

### 6.2 Removing Low-Frequency Signal Content

#### 6.2.1 JPEG Artifact Removal

#### 6.2.2 Non-Rigid Structure From Motion

### 6.3 Tensorflow and Keras

#### 6.3.1 Using Shared Weights and Shared Layers

#### 6.3.2 Custom Partial Derivatives

#### 6.3.3 Updating Tensorflow Variables After Applying Gradients

#### 6.3.4 The Perils of Using Built-In Functions For Complex Data

## 7 Conclusion

A brief review of my novel contributions and how it relates to other research.

## 8 Appendices

8.1 Diagonalization of Factored Rank-2 Matrices, Edge Cases

8.2 No Minimizer? No Problem! Use an Infimumizer Instead

8.3 Stronger Constraint for Low-Rank Approximation: How Much Stronger is it, Really?

## 9 References