E. Material Recognition

CX4042 – Deep Learning & Neural Networks

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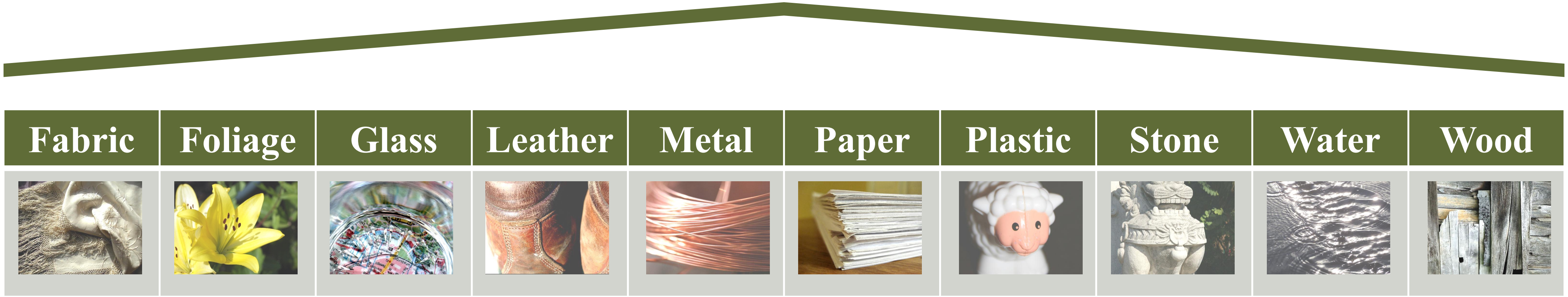
Agenda

1. Context
2. Data Processing
3. Models
4. Data Augmentation
5. Masks
6. Results
7. Garbage Classification
8. Key Takeaways

Introduction

Classify Materials from Image



Flickr Material Database:
10 categories & 100 images / category

- 500 close-up images
- 500 full object images

Related Work

1

Random Guessing Accuracy: 10%

2

Best Model Accuracy: 84% (Liu et. al, 2016)

3

Human Accuracy: 84.9%

Notable Models:

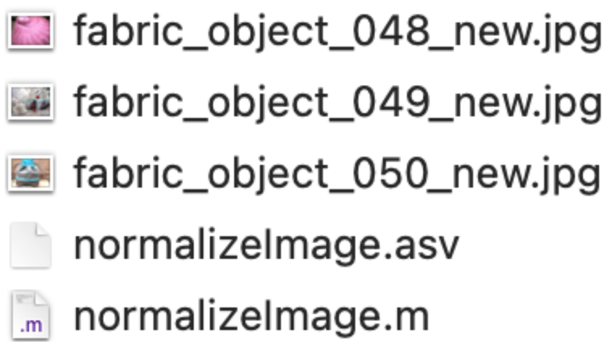
SVM-classifier with masks: 57.1% (Sharan et. al, 2013)

SVM-classifier + AlexNet: 69.6% (Bala et. al, 2015)

Transfer Learning LeNet: 64% (Lensch & Wielschollek, 2016)

Pre-Train + Transfer Learning: 84% (Liu et. al, 2016)

Data Preprocessing



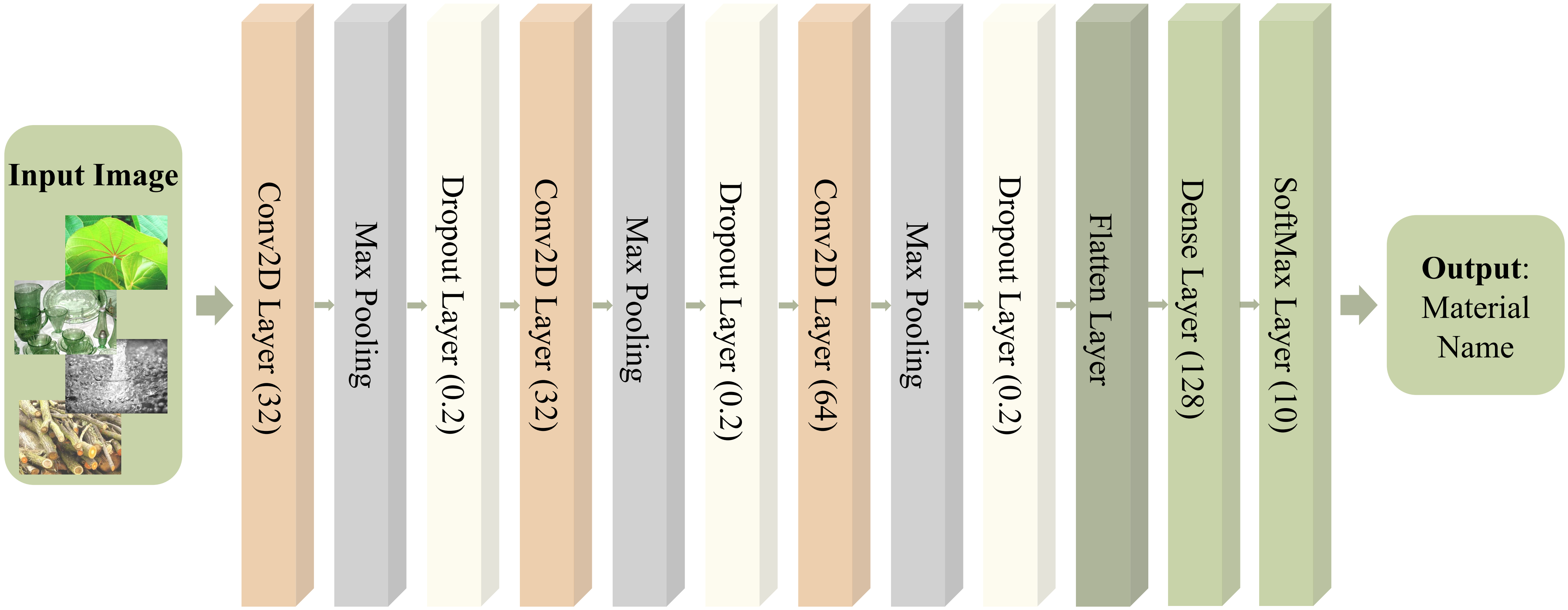
1. Remove Non *JPG* Files

2. Remove Grayscale Images

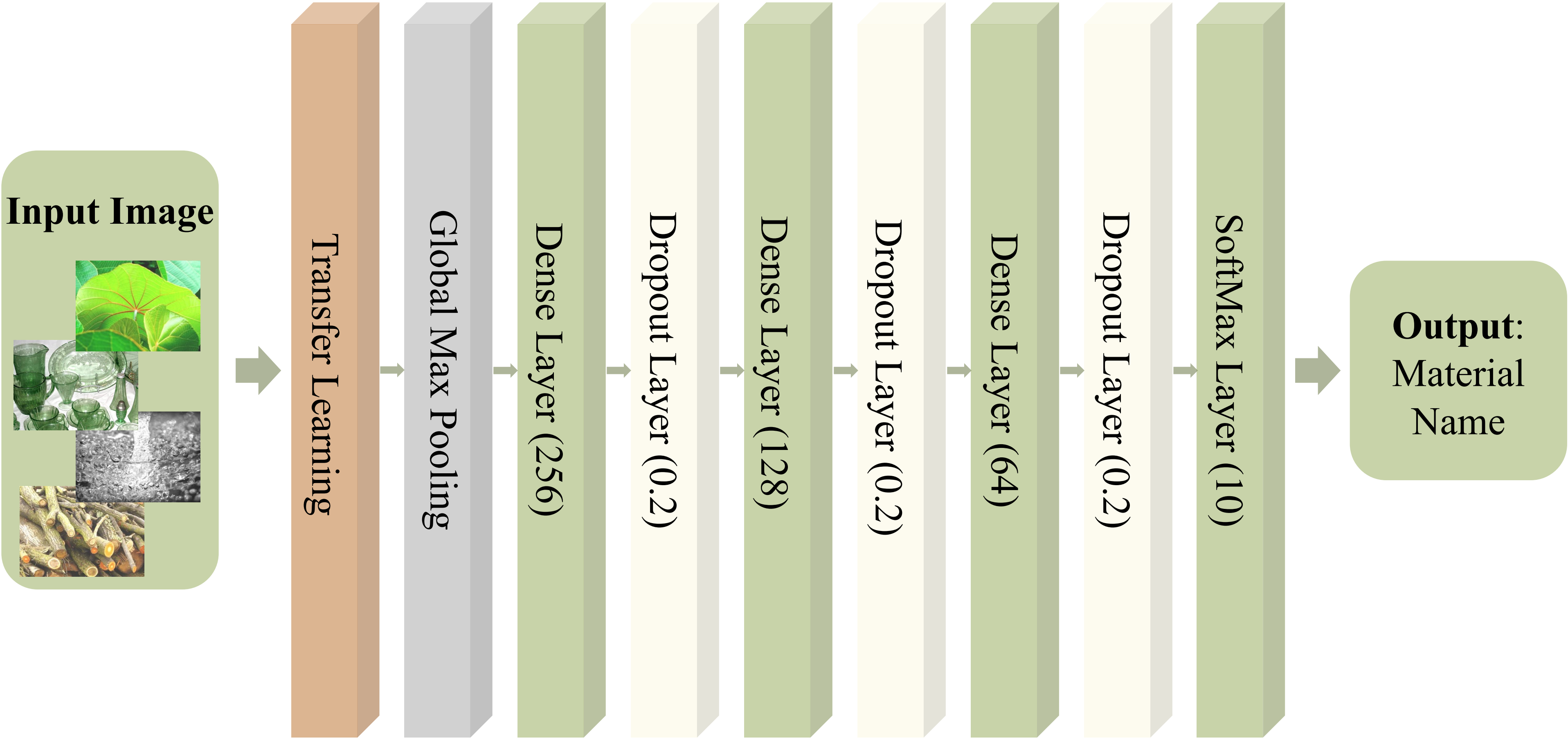
New Image Size: (150, 150)
Normalize: from 0-255 to 0-1

3. Resize & Normalize

Vanilla CNN Model



Transfer Learning



Models:

- Vanilla CNN
- TF - VGG16
- TF - ResNet50
- TF - Xception
- TF - MobileNet
- TF - DenseNet121
- TF - DenseNet201
- TF - EfficientNetV2B0
- TF - InceptionV3

* *TF: transfer learning*

Step 1

Train all the Models on the Training Dataset and Record Validation Accuracy

Step 2

Use Best Architecture to Run Further Experiments: Data Augmentation, Masks…

Step 3

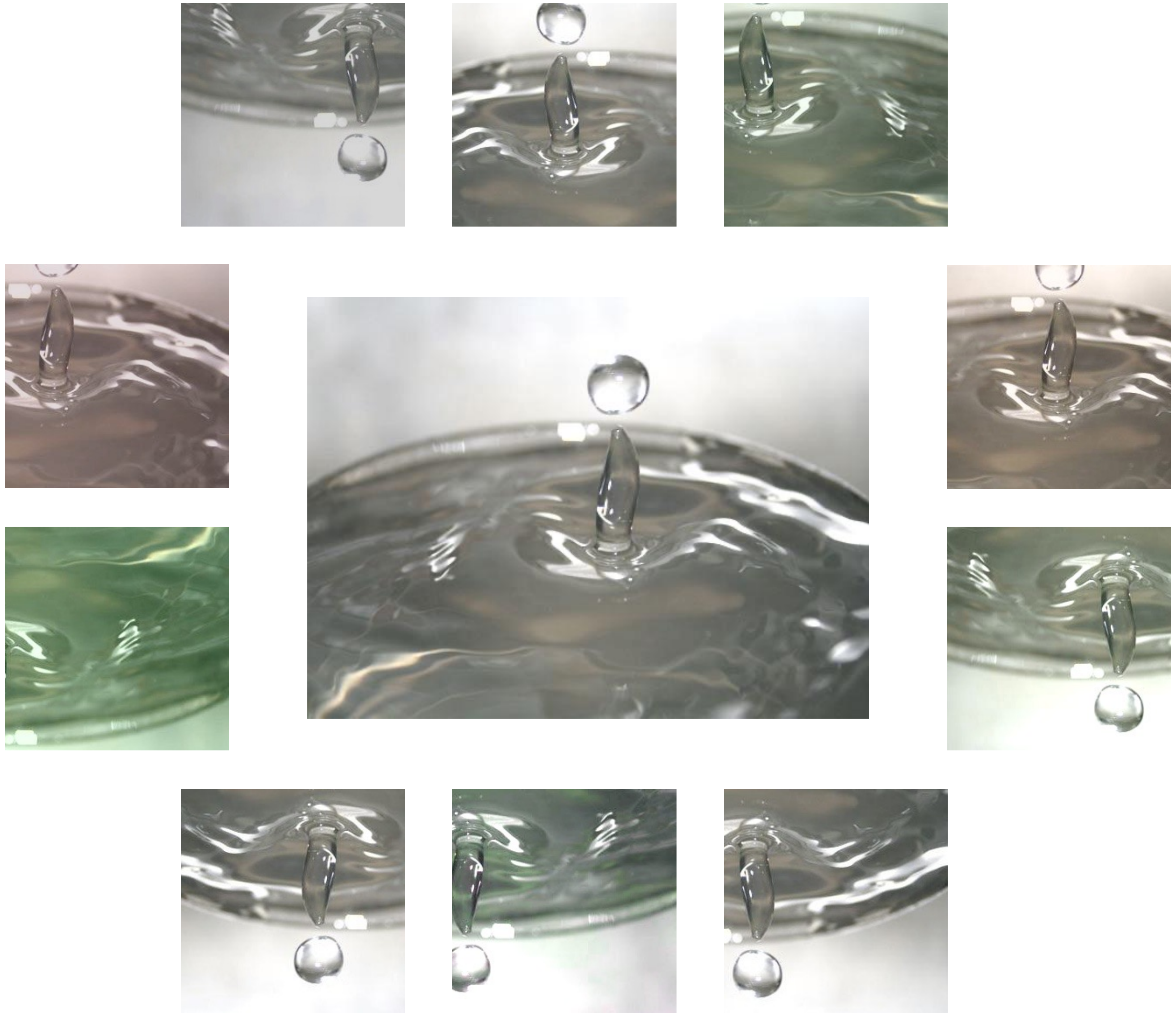
Compare Validation Accuracies to Determine Best Performing Model

Step 4

Re-Train Best Model on Train & Validation Dataset and Record Test Accuracy

Data Augmentation

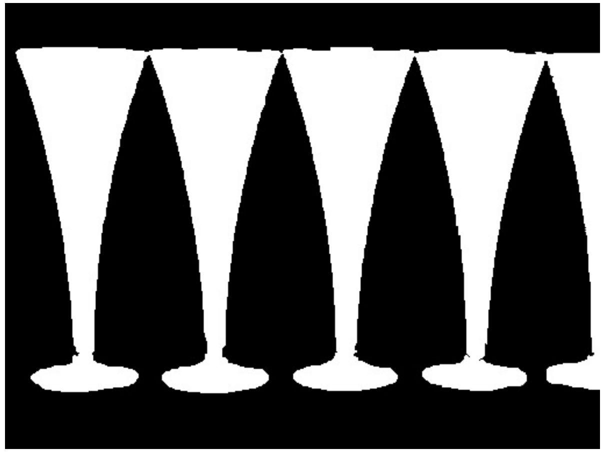
- **Random Crop** (w=256, h=256)
- **Horizontal Flip** (p=0.5)
- **Vertical flip** (p = 0.5)
- **RGB shift** (p = 0.4)
- **Color Jitter** (p = 0.2)
- **Brightness Contrast** (p = 0.2)



Applying Masks to Images

Original Image

Mask

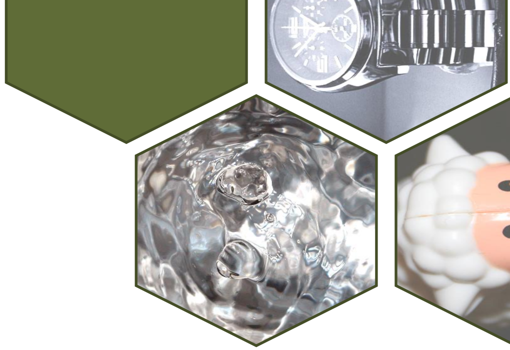


Object of Interest

Hyperparameter Optimization

Model	Val Accuracy	Learning rate	Dropout rate	Size dense layers
DenseNet201	0.7940	0.0023	0.4	256/192/48
Xception	0.7549	0.00017	0.3	256/128/48

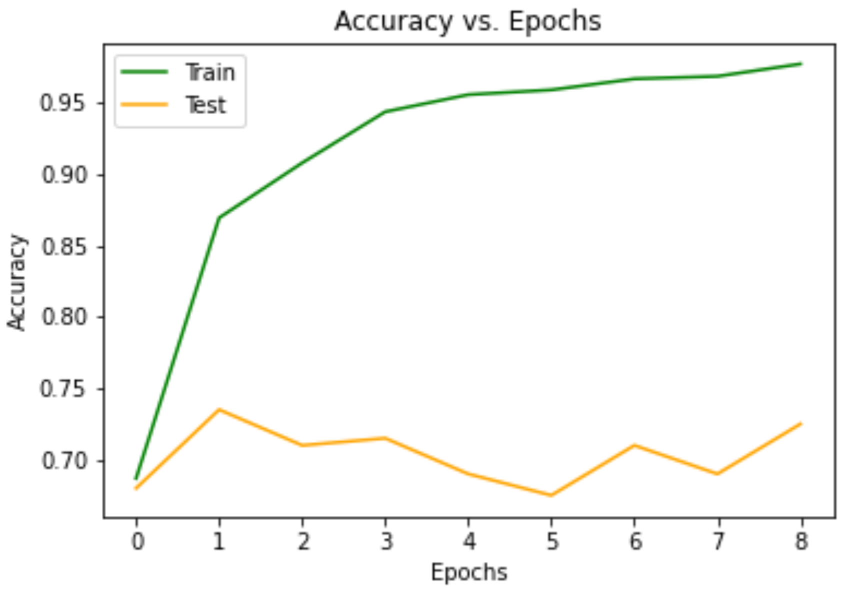
Hyper Parameter	Ranges	Step Size
Units Dense layer 1	(128 – 512)	128
Units Dense layer 2	(64 – 256)	64
Units Dense layer 3	(16 – 64)	16
Learning rate	(0.0001 – 0.01)	Log sampling
Dropout probability	(0.1 – 0.5)	0.1

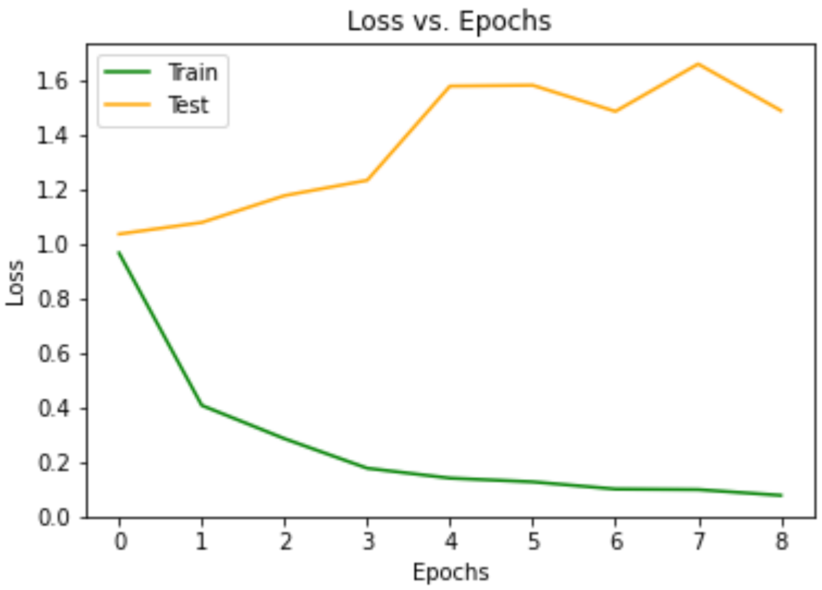


Results – Best Model

Xception on Augmented Data: 73.5% Accuracy

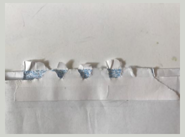
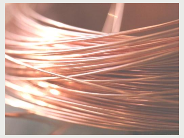
Class	Precision
Fabric	0.667
Foliage	0.857
Glass	0.714
Leather	0.824
Metal	0.654
Paper	0.8
Plastic	0.615
Stone	0.812
Water	0.783
Wood	0.714





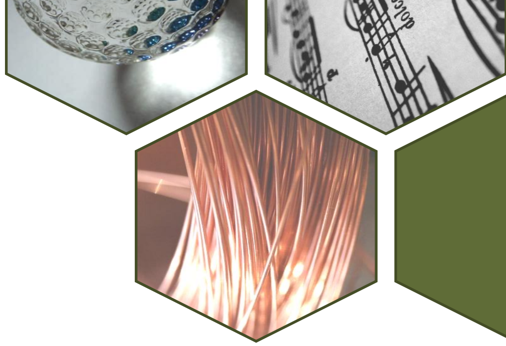
Garbage Classification

Classify Garbage

	Cardboard	Trash	Glass	Metal	Paper	Plastic
Garbage						
Flickr	N/A	N/A				

Accuracy: 52% using model

Source: Garbage Dataset (Kaggle): https://www.kaggle.com/datasets/asdasdasasdas/garbage-classification



Key Takeaways

High Accuracy

Better performance than majority of models in literature… but lower than human performance and state-of-the-art model

73.5% accuracy
vs
84% accuracy

Simplicity

Main Benefit: Simpler Approach than the State-of-the-Art Model, easier to code and use

Transfer Learning
&
Dense Layers

Generalization

Approach is suitable for practical applications as it is easy to run and achieves decent performance on practical examples

Garbage Accuracy:
52%