Solid Domestic-Waste (SDW) Classification using Computer Vision

Author: Daniel Otero Gómez
Advisors: Mauricio Toro Bermúdez and Juan Camilo Ramirez

UNIVERSIDAD EAFIT

Team Presentation

Daniel Otero Gómez

Mauricio Toro

Juan Camilo Ramirez

Agenda

Introduction | Business Context

Implemented Models

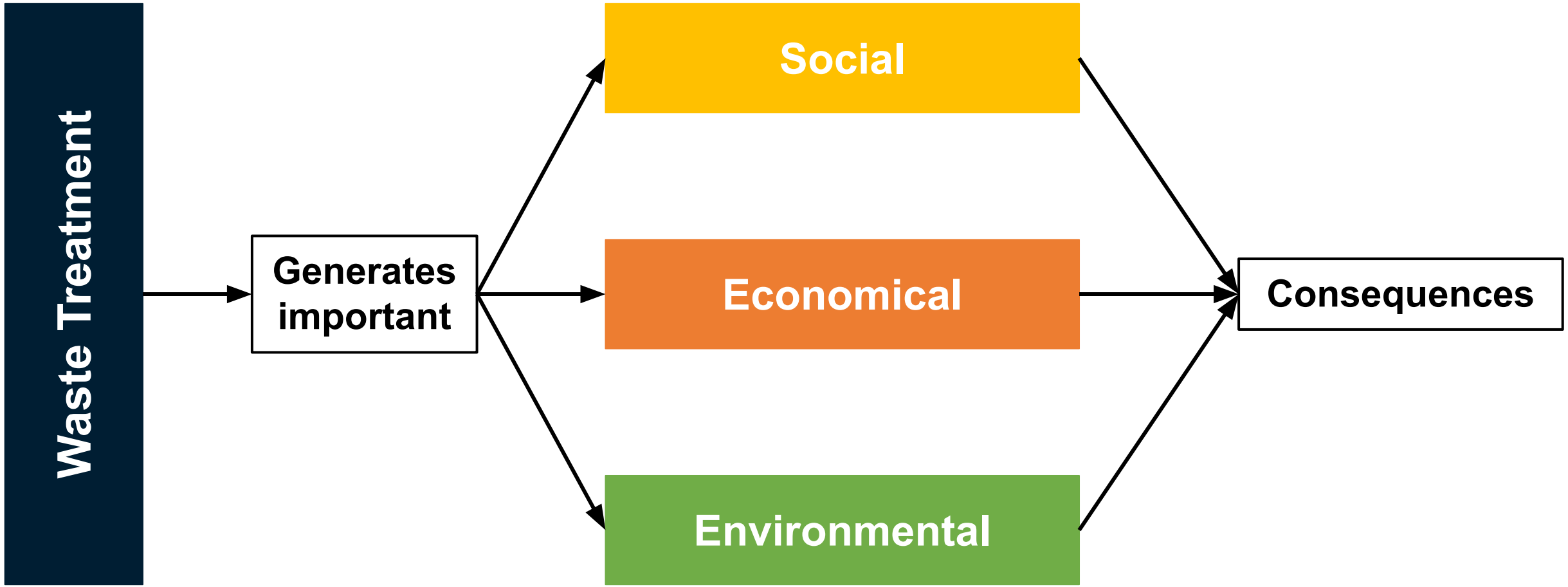
Results

Further Work

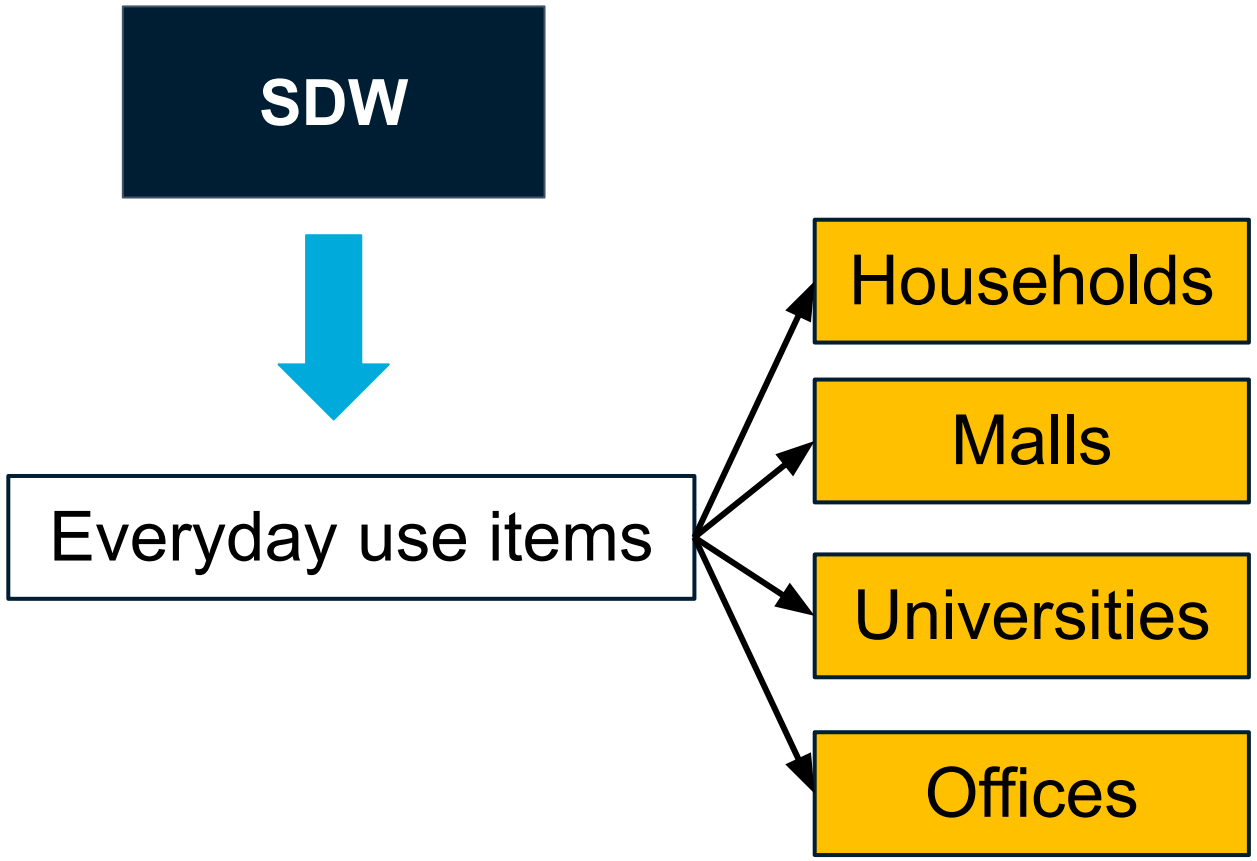
Mathematical Background

References

Introduction



Introduction



In developing countries, municipal waste is mostly composed of SDW

55-88% Households

10-30% Comercial Centers

Introduction

Waste Classification System

Improves and automatizes the waste segmentation process

by...

Eliminating human extensive labor

Speeding the process

Allowing...

to give wastes proper treatment and prevent environmental damages

General Objective

Merge 3 Worklines

Data Augmentation

↓

Enlarge the dataset to improve model training

Image Classification

↓

Perform the classification

Object Detection

↓

Preprocess images and produce initial prediction

Introduction

Images

Recyclable Organic

Paper

403

Cardboard

Textiles

Recyclable Inorganic

Plastic

410

Metal

Tetra Pak Containers

Glass

Non-Recyclable

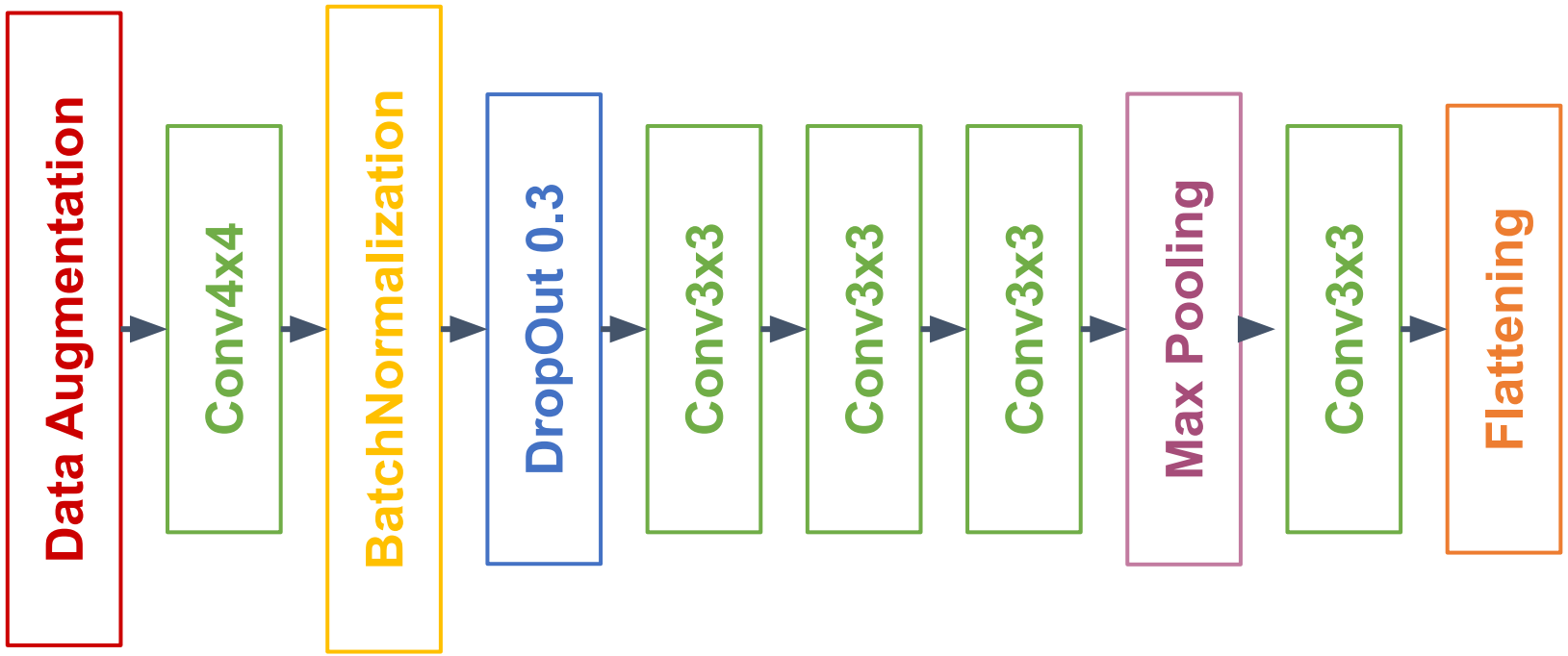
Sanitary

Electronics

Implemented Models

Convolutional Neural Network

- Random Flip
- Random Rotation
- Random Translation
- Random Contrast
- Resizing

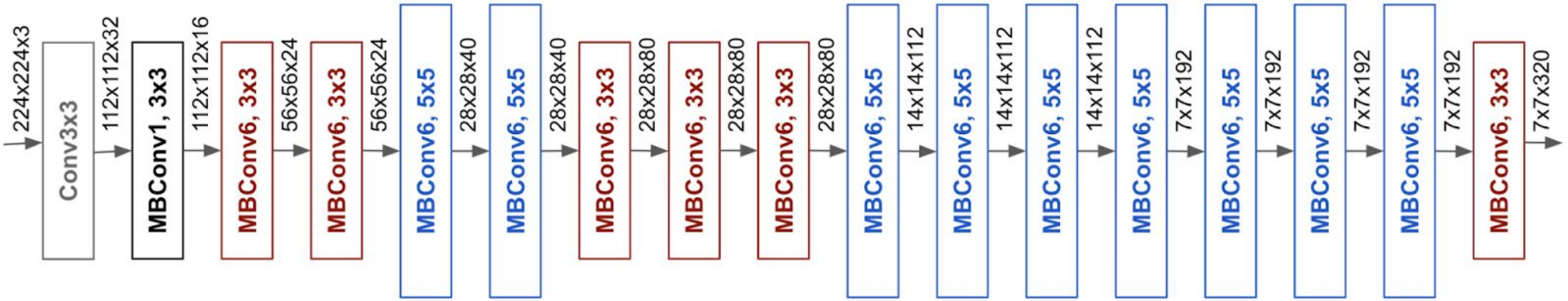


Implemented Models

Google's Efficient Net B0

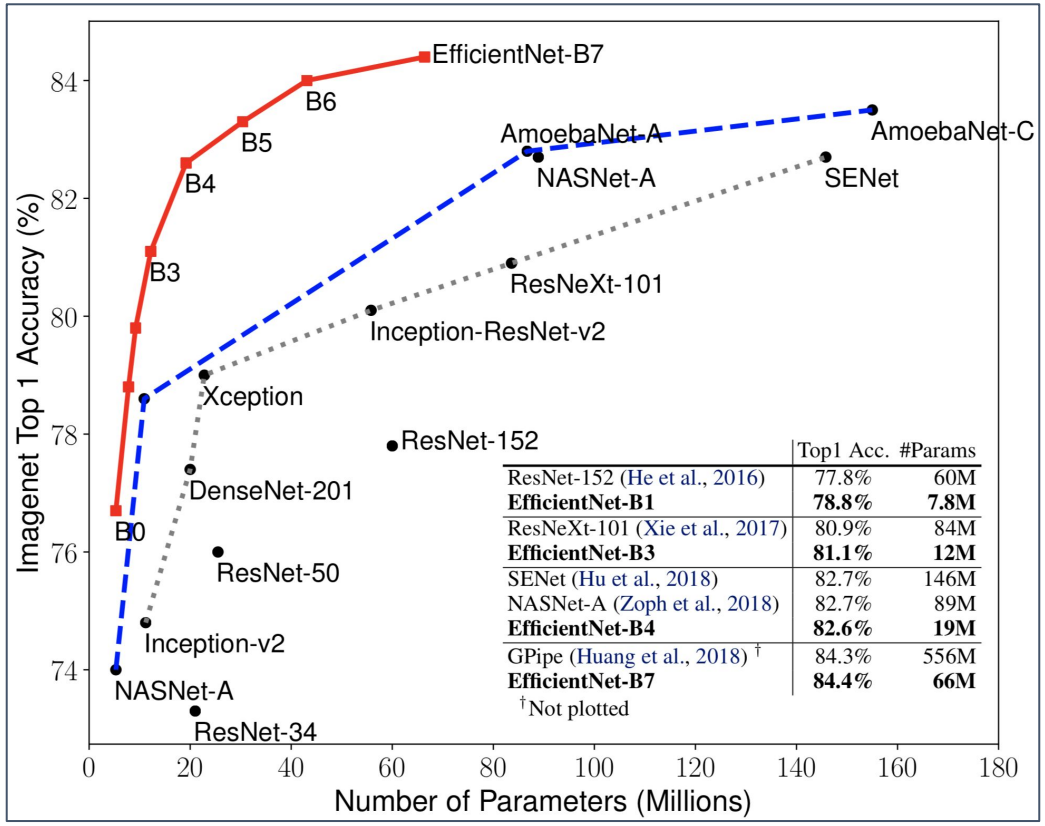
Simpler Architecture

Outstanding Results



Google AI Blog (2019).

Parameter Comparison



	Top1 Acc.	#Params
ResNet-152 (He et al., 2016)	77.8%	60M
EfficientNet-B1	**78.8%**	**7.8M**
ResNeXt-101 (Xie et al., 2017)	80.9%	84M
EfficientNet-B3	**81.1%**	**12M**
SENet (Hu et al., 2018)	82.7%	146M
NASNet-A (Zoph et al., 2018)	82.7%	89M
EfficientNet-B4	**82.6%**	**19M**
GPipe (Huang et al., 2018) †	84.3%	556M
EfficientNet-B7	**84.4%**	**66M**

†Not plotted

Google AI Blog (2019).

Results

Model Comparison

10-Fold CV

- Logistic Regression
- SVM
- KNN

Train-Validation-Test Split

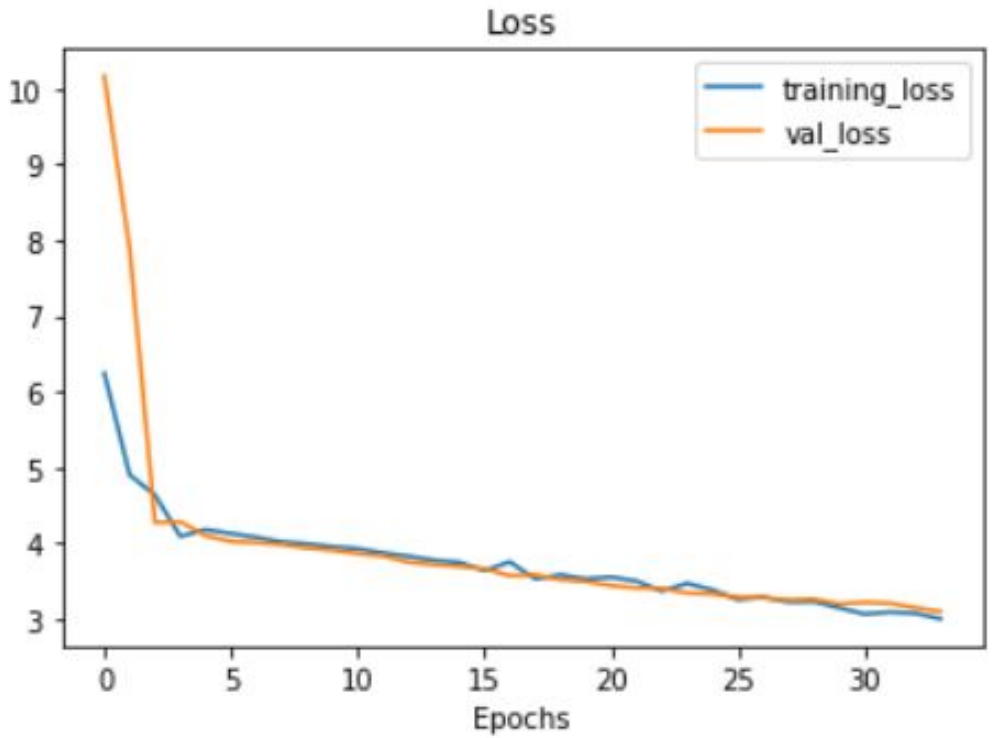
- CNN
- TL Feature Extraction
- TL Fine-Tuning

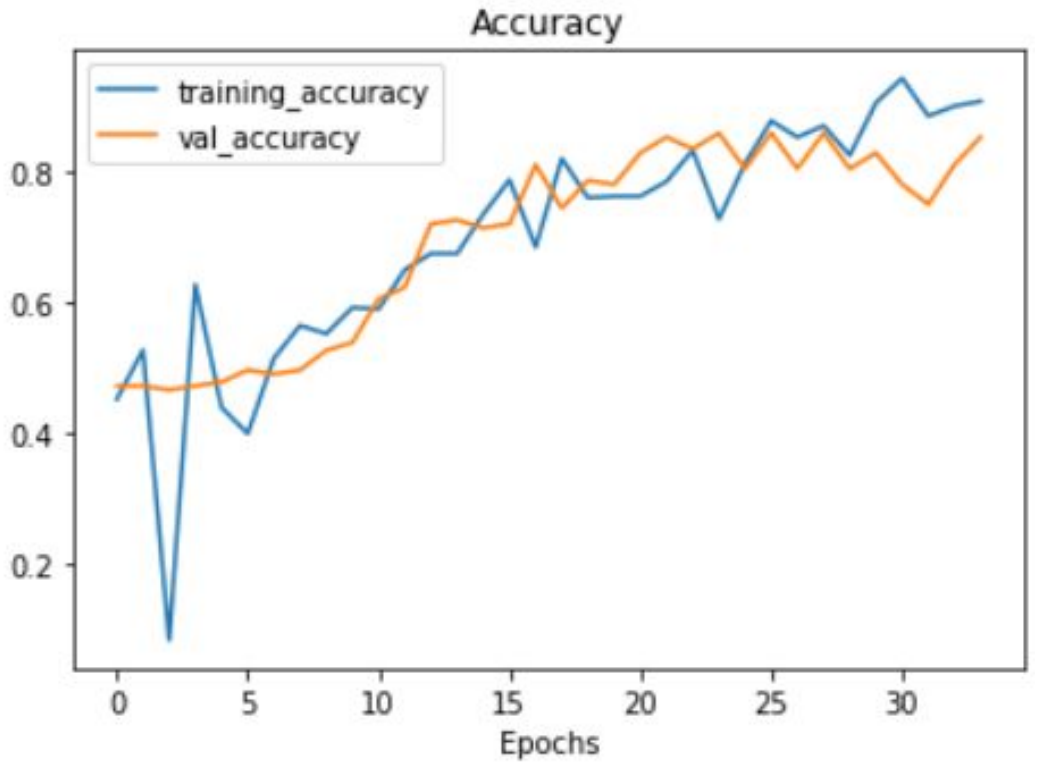
Note: Trained for 50 epochs max. and used EarlyStopping with patience of 10 to

UNIVERSIDAD EAFIT®

Results

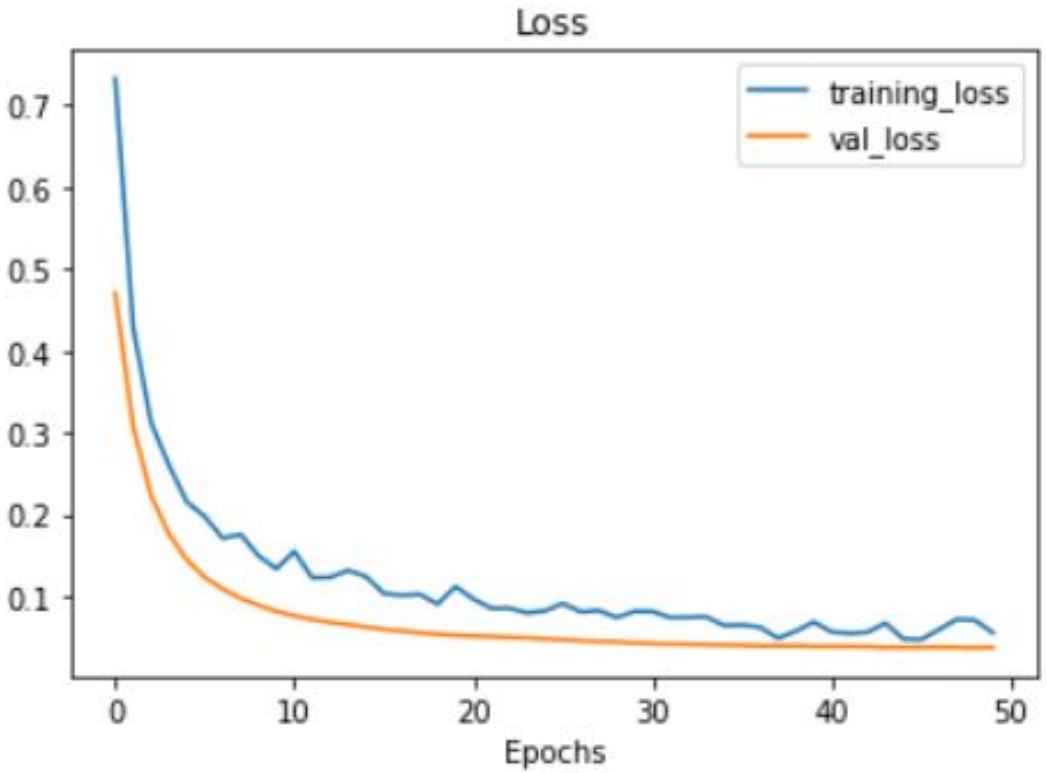
Convolutional Neural Network

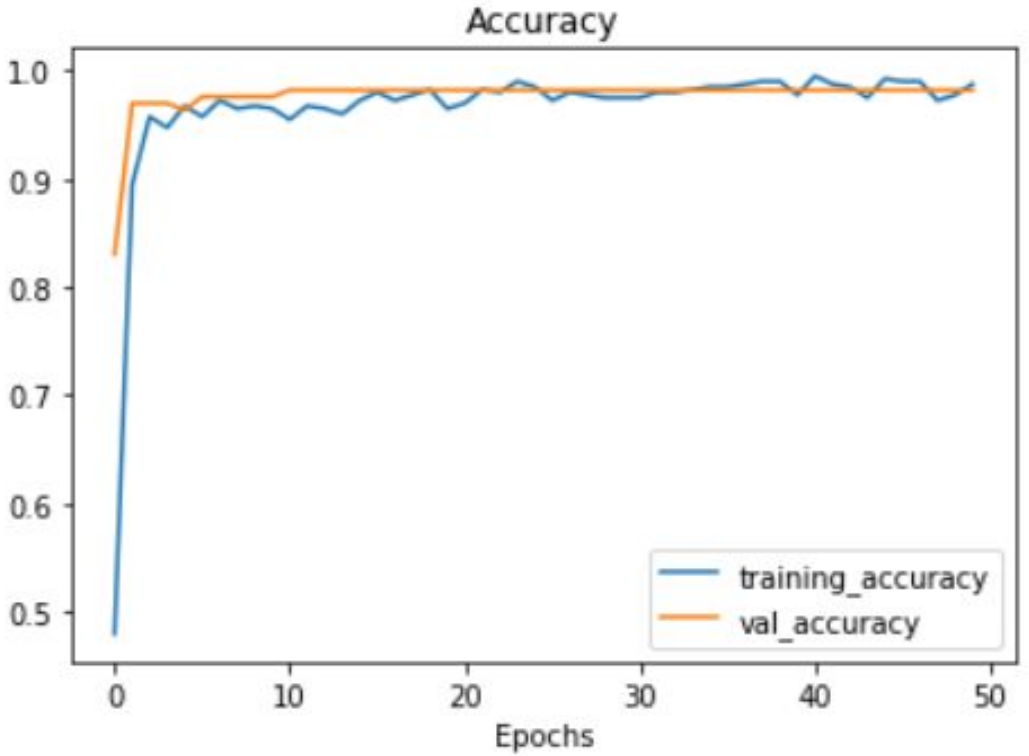




Results

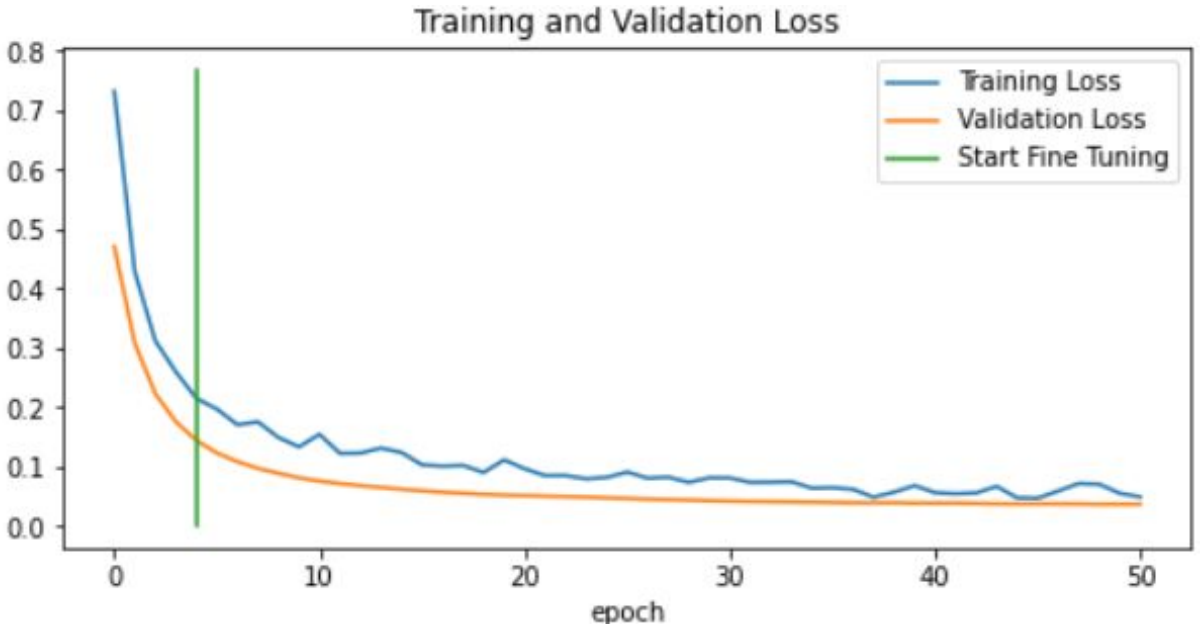
TL Feature Extraction

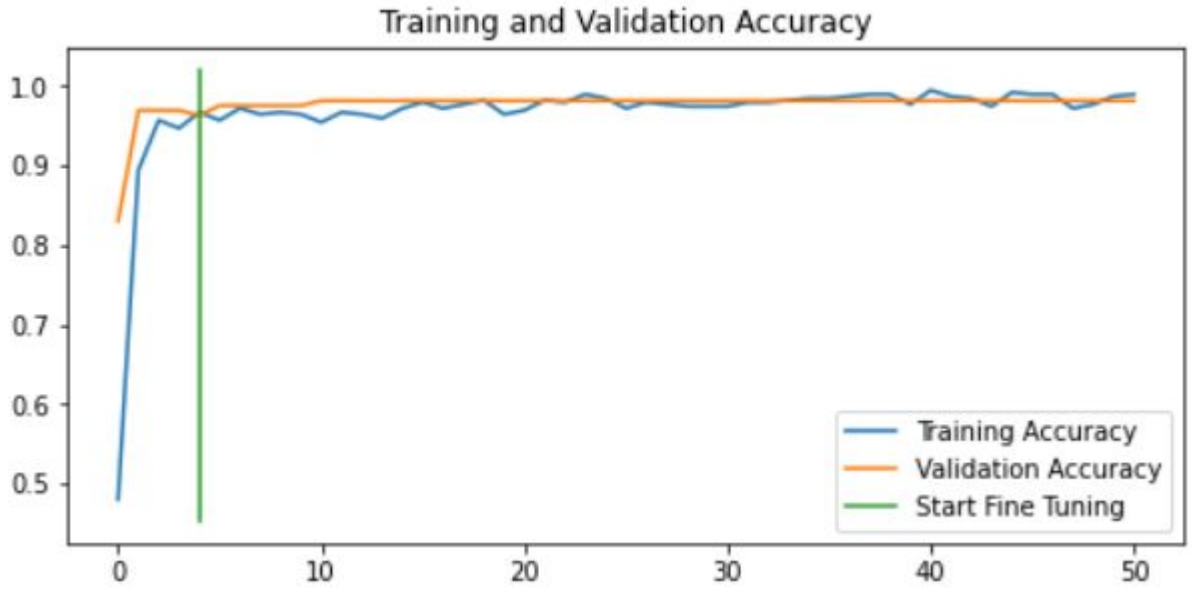




Results

TL Fine Tuning

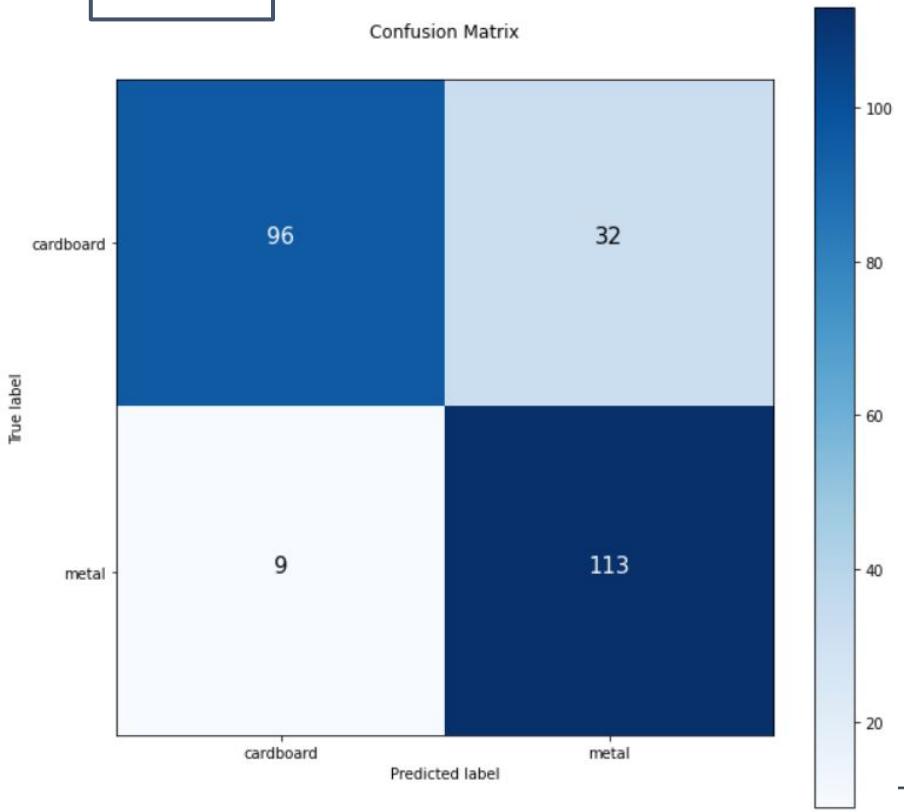




Results

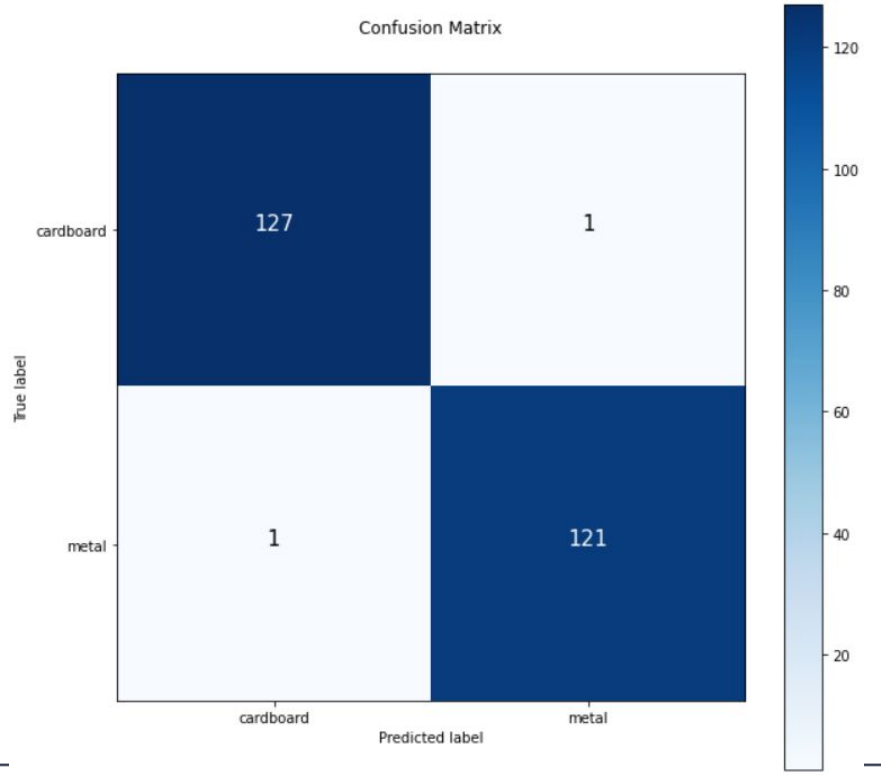
Confusion Matrix

CNN



AUC Score: 0.838

TL



AUC Score: 0.988

UNIVERSIDAD EAFIT®

Results

Past Results

Results

Experiments and Code

TensorFlow Hub

https://tensorboard.dev/experiment/iJBN0O4wQ8qDdMjKfQUdrA/#scalars&_smoothingWeight=0.706

https://github.com/daoterog/Solid_Domestic_Waste_Image_Classification

Future Work

Tackle the Multi-Class Problem

Implementation of functioning web platform

Integrate the different worklines together

Include other types of learning (e.i. self supervised learning)

Models

- Convolutions in Neural Networks:

$$
\begin{aligned}
n_{out} &= \left\lfloor \frac{n_{in} + 2p - k}{s} \right\rfloor + 1 \\
j_{out} &= j_{in} * s \\
r_{out} &= r_{in} + (k-1) * j_{in} \\
start_{out} &= start_{in} + \left(\frac{\mathrm{k} - 1}{2} - \mathrm{p} \right) * j_{in}
\end{aligned}
$$

- Transfer Learning:

$$Domain = \{x, P(X)\}$$

$$Task = \{\gamma, P(Y|X)\}$$

Models

- Logistic Regression:

$$P = \frac{e^{a+bX}}{1 + e^{a+bX}}$$

- K Nearest Neighbors (KNN):

$$\mathrm{d}(\mathbf{p}, \mathbf{q}) = \mathrm{d}(\mathbf{q}, \mathbf{p}) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 + \cdots + (q_n - p_n)^2}$$

$$= \sqrt{\sum_{i=1}^{n} (q_i - p_i)^2}.$$

Models

- Support Vector Machines:

$$f(x_{test}) = \sum (\alpha_i L_i(\mathbf{x}^\intercal x_{test}) + b)$$

References

- Aguilar-Virgen, Quetzalli, Vega, Carolina, Taboada-Gonz´alez, Paul, & Aguilar, Xochitl. 2010. Potential Recovery of Domestic Solid Waste Disposed of in A Landfill. Revista de Ingeniería, 11, 16–27.
- Andesco. 2020. El 78% de los hogares colombianos no recicla . Andesco. Accessed: 2021-02-05.
- Google AI Blog. 2019. EfficientNet: Improving Accuracy and Efficiency through AutoML and Model Scaling. Google AI Blog. Accesed: 2021-09-27.
- Liu, Peng, Choo, Kim-Kwang Raymond, Wang, Lizhe, & Huang, Fang. 2017. SVM or deep learning? A comparative study on remote sensing image classification. Soft Computing, 21 (12).
- Zhihong, Chen, Hebin, Zou, Yan, Wang, Yanbo, Wang, & Binyan, Liang. 2018. Multi-task DetectionSystem for Garbage Sorting Base on High-order Fusion of Convolutional Feature HierarchicalRepresentation. 5426–5430
- Sakr, George, Mokbel, Maria, Darwich, Ahmad, Khneisser, Mia, & Hadi, Ali. 2016 (11). Comparing Deep Learning And Support Vector Machines for Autonomous Waste Sorting.
- Semana, Revista. 2020. As cambiar´a el reciclaje en Colombia tras entrada en vigencia de una norma. Revista Semana. Accessed: 2021-02-05.
- Sunarti, Sunarti, Tjakraatmadja, J.H., Ghazali, Achmad, & Rahardyan, B. 2020. Increasing resident participation in waste management through intrinsic factors cultivation. 12.
- Wolf, Thomas, Sanh, Victor, Chaumond, Julien, & Delangue, Clement. 2019. Transfertransfo:A transfer learning approach for neural network based conversational agents.arXiv preprintarXiv:1901.08149.

THANK YOU!