

ThrashAssistant

A kivy App, which uses Deep Neural Networks, for helping trash segregation

Olgun AYDIN
Krystian Zieliński



Content :

- Introduction
- Transfer Learning
- Two approaches for classification task
- KivyApp



Introduction

Municipality in Gdansk started to be really strict about segregating trash last year. They are checking segregation performance of residential buildings and providing opportunity to pay less tax to those people who live in the buildings which have better segregation performance.

Also, municipality fine the companies which don't follow the segregation instructions. Even though, instructions are well defined still sometimes people are confused to decide which trash bin they should use.

We have realized that having a mobile app which will guide people about this purpose would be very helpful. We have developed deep neural networks (DNN) using transfer learning. DNNs have been trained by using keras Python library. After having good performed model, kivy app has been developed.



POLISH NATIONWIDE SYSTEM FOR SORTING WASTE

glass paper metals and plastics bio non-recyclable

Since April 2018 in Gdańsk

WASTE SEGREGATION PRINCIPLES IN GDANSK FROM APRIL 2018



	Glass GREEN BIN/BAG
<input checked="" type="checkbox"/> Put in:	<ul style="list-style-type: none"> empty drink bottles empty jars (lids removed) glass cosmetics packaging
<input type="checkbox"/> Do not put in:	<ul style="list-style-type: none"> ceramics, flower pots, ceramic ware, porcelain, crystal glassware kitchen dishes, tampered glass tableware and kitchenware, heat-resistant glass vigil lights with wax light bulbs, fluorescent bulbs and reflectors mirrors and glass panes medication, oil, chemical packaging
	Bio BROWN BIN
<input checked="" type="checkbox"/> Put in:	<ul style="list-style-type: none"> vegetable and fruit peelings and waste food waste trimmings and grass clippings used paper towels and tissues
<input type="checkbox"/> Do not put in:	<ul style="list-style-type: none"> soil, stones and ash disposable nappies and other hygiene products animal faeces and faeces soiled materials animal bones and raw meat impregnated wood and chipboard
	NON-RECYCLABLE GREY/BLACK BIN
<input checked="" type="checkbox"/> Put in:	<ul style="list-style-type: none"> anything that cannot go into any of the bins, or cannot be recycled
<input type="checkbox"/> Do not put in:	<ul style="list-style-type: none"> non-typical and hazardous waste

HOW TO HANDLE NON-TYPICAL AND HAZARDOUS WASTE?

Green waste - put the bags on collection day next to the bin store

Bulky waste and tyres - put these next to the bin store by 6.00 am on collection day or after 9.00 pm on the day before

Building and refuse - deliver these to the PSZOK (Municipal Waste Sorting Facility), you can dispose of up to 2 tonnes of such waste for free in a calendar year per each home or order a special service from a waste contractor for a fee

Medication - put it into special bins placed in pharmacies

Used electrical appliances and white goods - take them back to the shop when you buy new items, hand them over to a hazardous waste collection service or deliver to the PSZOK

Other **hazardous waste** (such as paint, thermometers, fluorescent bulbs, batteries and accumulators) - hand it over free of charge to the vehicle crew of a **hazardous waste collection service** operated by Gdańsk Municipal Services www.guk.gda.pl

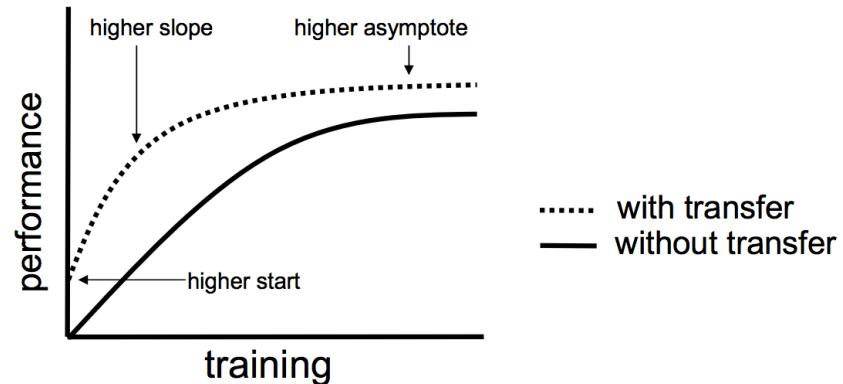
Don't forget to take advantage of the **Municipal Waste Sorting Facility (PSZOK)** and deliver your sorted municipal waste there, including hazardous waste. The PSZOK is part of the Gdańsk Waste Treatment Facility at 55 Jabłoniowa street www.zut.com.pl

Ash goes into the non-recyclable bin. Make sure it is cool and cannot start a fire. You can also apply in writing to City Hall for your plastic bin to be replaced with a metal one.



Transfer Learning

- TL is a task for using past experiences to transfer the information learned in one or more tasks and to improve learning on a related task.
- The techniques that provide information transfer aim to make ML as efficient as human learning. Transfer methods are heavily dependent on ML algorithms used to learn tasks.





Dataset

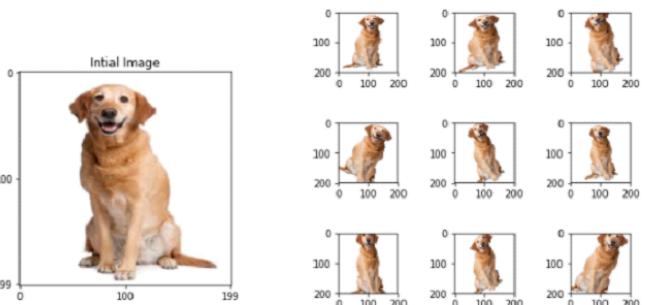
For dataset we used pictures available on Kaggle (wangzhang/waste-pictures and katexu/trash_detection). Size of them were set to 224x224. Train set included 3238 observations, test set 807. We tried 2 different approaches for classification :

- 4 Labels - glass, paper, plastic & metal, non-segregable trash
- 8 Labels - cardboard, glass, metal, milk box, paper, plastic, plastic bag, trash

There's always a trade-off. With 4 Labels model has less choices to make, therefore accuracy might be higher. However, structure of e.g. milk box and plastic bag differs a lot, so predicting them separately should increase model performance.



Dataset



During training of the model we used generator with additional **rescaling**, **shear_range**, **zoom_range** and **horizontal_flip**.





Training models

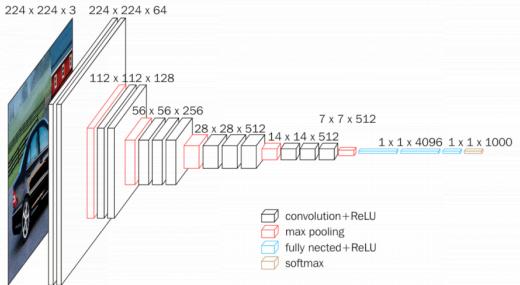
- For training model we used Google Colab with usage of **TPU**. TL was carried out using the VGG16 network with 2 additional **relu dense**, **softmax dense** and two additional **dropout** layers.
- Early stopping method was used by monitoring validation loss.
- Models were compiled with **adam** optimizer and **categorical cross entropy** loss.
- Average computation time per epoch was 52 second.





Training models

- For each approach we trained various different models. We tried each combination of batch size (16,32,64) and frozen layers in VGG16* (last 4,8,12).



- Training process was done using **Tensorflow** Python library.
- VGG model was used with initial weights from learning imagenet dataset.



Model: "vgg16"

Layer (type)	Output Shape	Param #
input_1 (InputLayer)	[None, 224, 224, 3]	0
block1_conv1 (Conv2D)	(None, 224, 224, 64)	1792
block1_conv2 (Conv2D)	(None, 224, 224, 64)	36928
block1_pool (MaxPooling2D)	(None, 112, 112, 64)	0
block2_conv1 (Conv2D)	(None, 112, 112, 128)	73856
block2_conv2 (Conv2D)	(None, 112, 112, 128)	147584
block2_pool (MaxPooling2D)	(None, 56, 56, 128)	0
block3_conv1 (Conv2D)	(None, 56, 56, 256)	295168
block3_conv2 (Conv2D)	(None, 56, 56, 256)	590080
block3_conv3 (Conv2D)	(None, 56, 56, 256)	590080
block3_pool (MaxPooling2D)	(None, 28, 28, 256)	0
block4_conv1 (Conv2D)	(None, 28, 28, 512)	1180160
block4_conv2 (Conv2D)	(None, 28, 28, 512)	2359808
block4_conv3 (Conv2D)	(None, 28, 28, 512)	2359808
block4_pool (MaxPooling2D)	(None, 14, 14, 512)	0
block5_conv1 (Conv2D)	(None, 14, 14, 512)	2359808
block5_conv2 (Conv2D)	(None, 14, 14, 512)	2359808
block5_conv3 (Conv2D)	(None, 14, 14, 512)	2359808
block5_pool (MaxPooling2D)	(None, 7, 7, 512)	0
<hr/>		
Total params:	14,714,688	
Trainable params:	14,714,688	
Non-trainable params:	0	



Training models

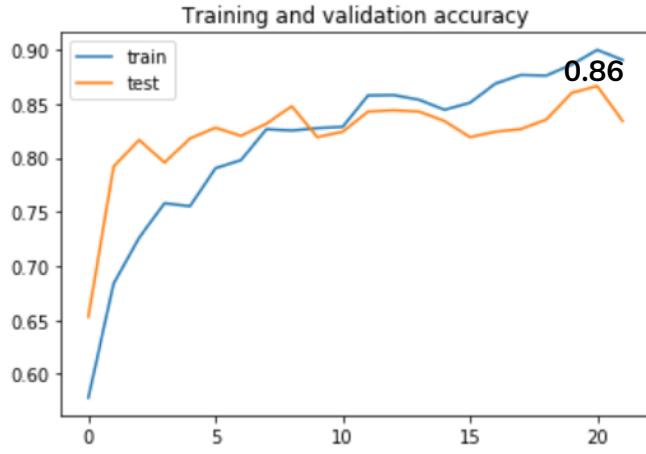
- Freezing layers in VGG16 is very easy. We can use simple loop (4 frozen layers) :

```
vgg_conv=VGG16(weights='imagenet', include_top=False, input_shape=(224,224,3))
for layer in vgg_conv.layers[-4:]:
    layer.trainable=False
```

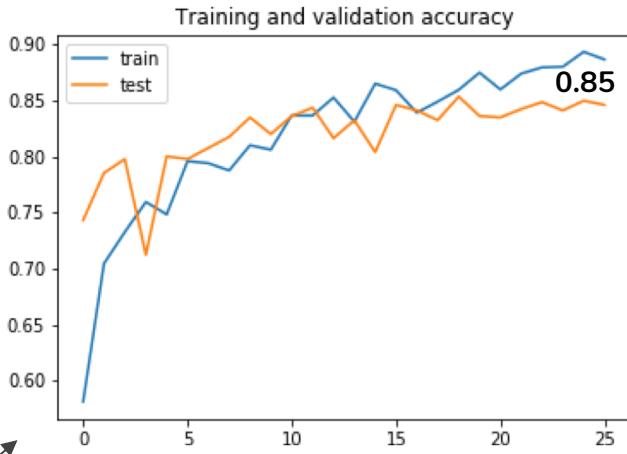
- And then we can combine VGG architecture with custom denses :

```
classifier=Sequential()
classifier.add(vgg_conv)
classifier.add(Flatten())
classifier.add(Dense(units = 256, activation = 'relu'))
classifier.add(Dropout(0.4))
classifier.add(Dense(128, activation = 'relu'))
classifier.add(Dropout(0.1))
classifier.add(Dense(4,activation='softmax'))
```

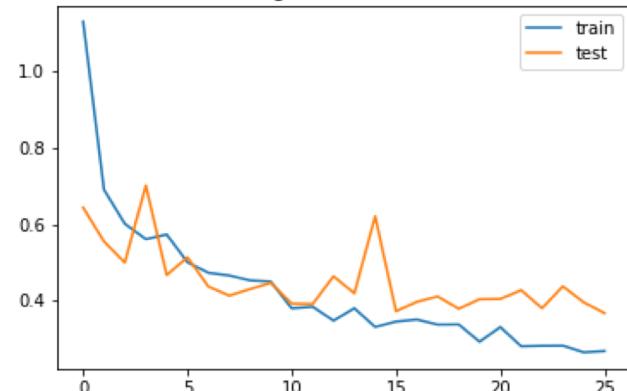
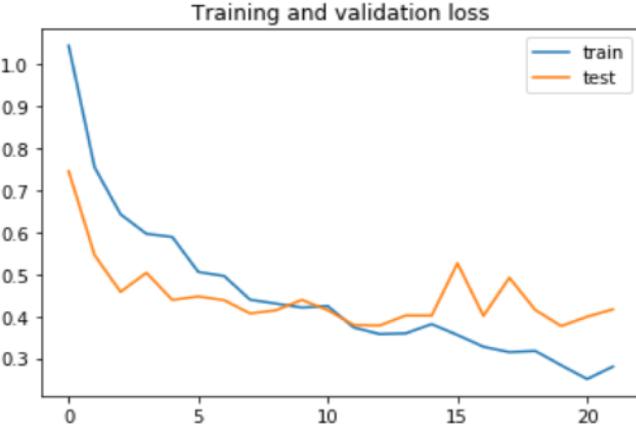
Comparison of different models (4 classes)



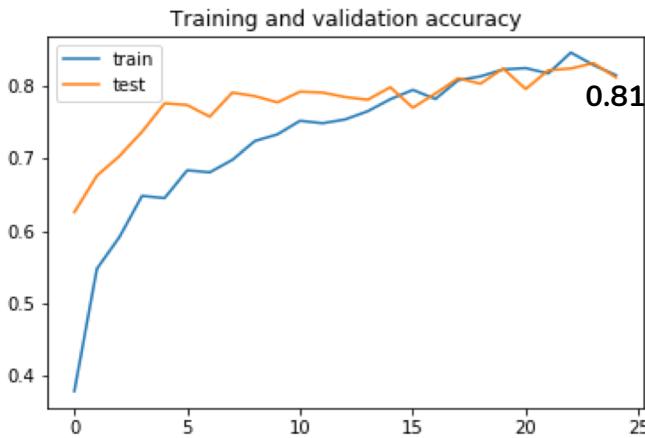
4 Frozen
Layers &
Batch size 16



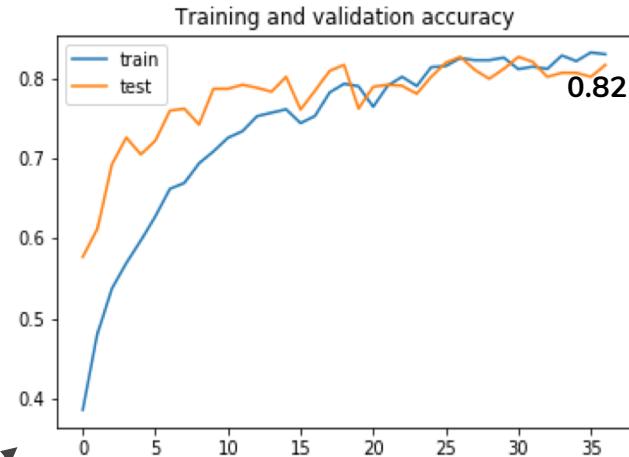
8 Frozen
Layers &
Batch size 32



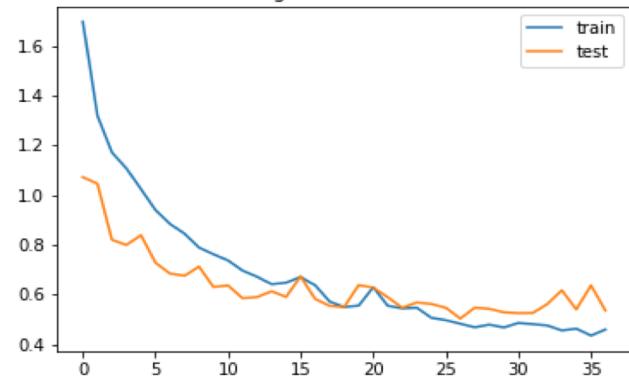
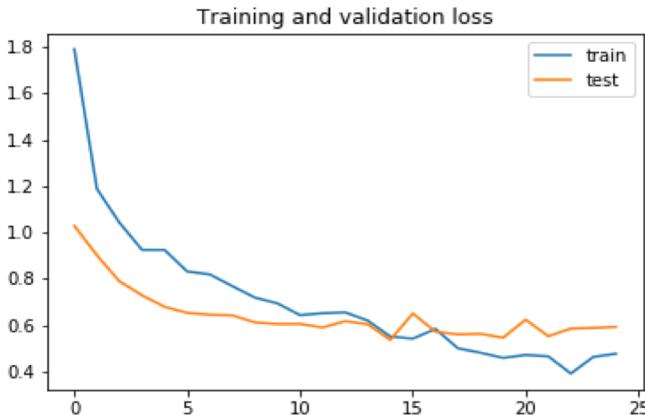
Comparison of different models (8 classes)



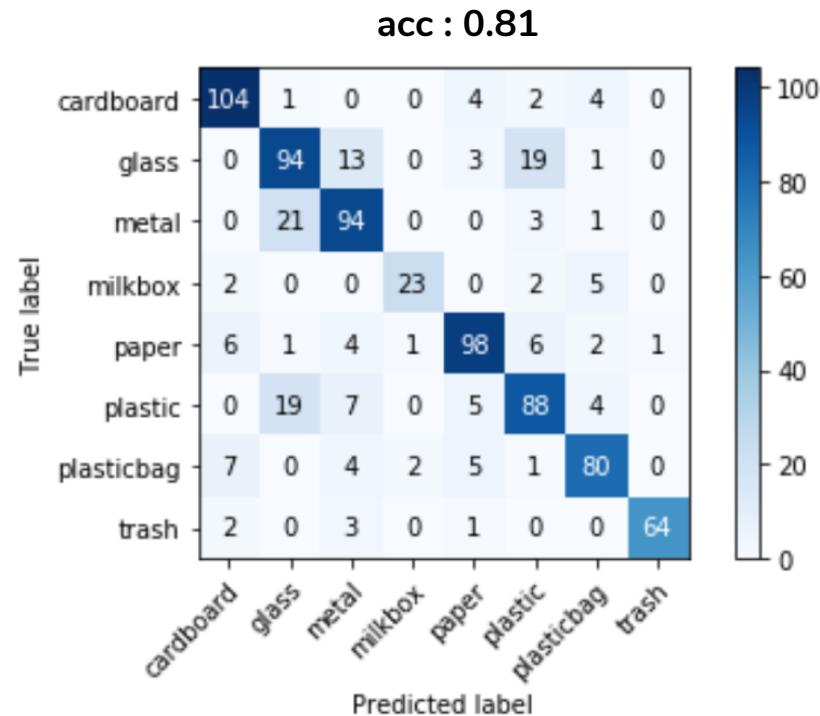
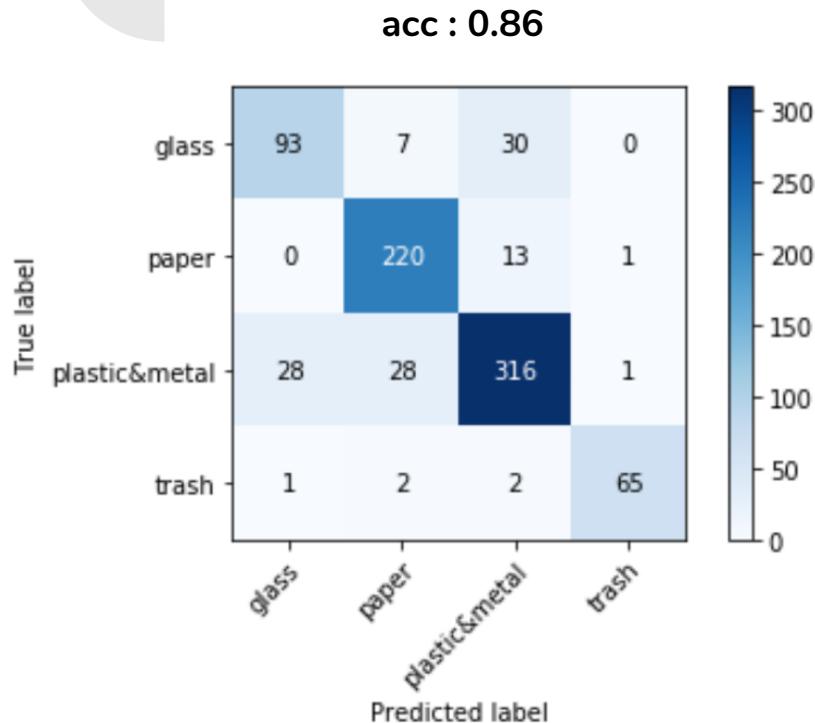
8 Frozen
Layers &
Batch size 32



12 Frozen
Layers &
Batch size 12



How about prediction performance per class?





Kivy App

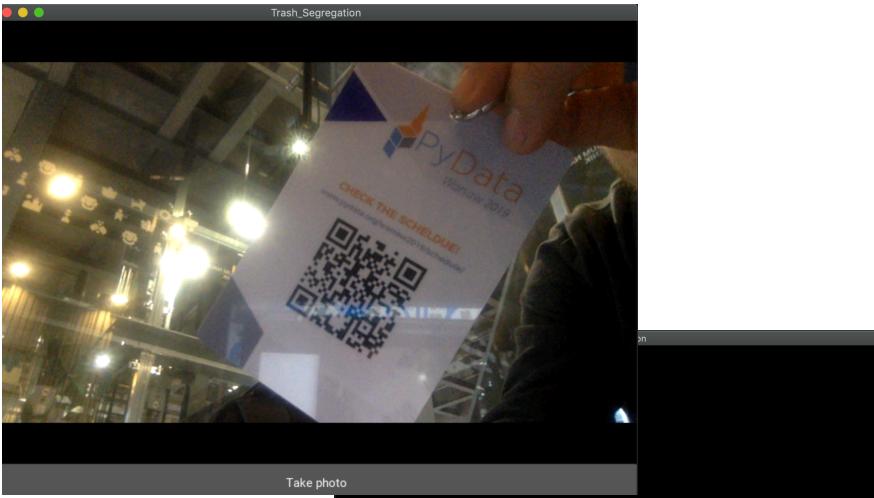
- Kivy - Open source Python library for rapid development of applications that make use of innovative user interfaces, such as multi-touch apps.

<https://kivy.org/#home>

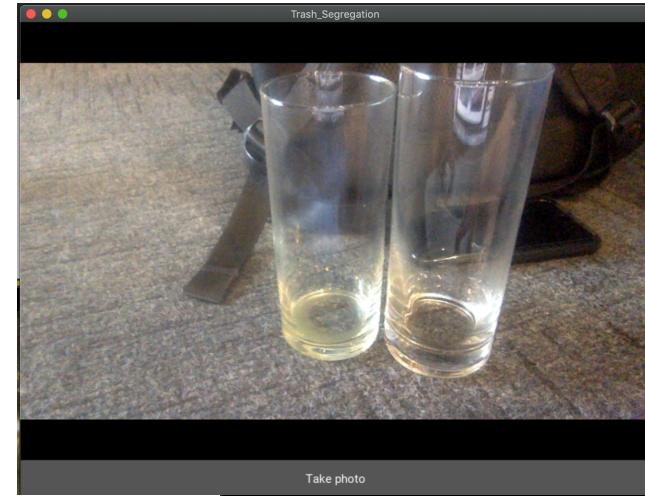




Application



Plastic



Glass



Thank you

For any questions, please don't hesitate to send us email.

Olgun AYDIN, olgun.aydin@pwc.com

Krystian Zieliński, krystian.zielinski@pwc.com