ARN - Laboratory 05

Anthony Coke, Mehdi Salhi, Guilain Mbayo

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Contents

Introduction

> describe the context of your application and its potential uses, briefly describe how you are going to proceed (methodology), that is, what data are you going to collect (your own pictures of.… , maybe extra-pictures collected from the web, etc), what methods are you going to use (e.g., CNNs, transfer learning)

Our application is made in the context of the course ARN (Apprentissage par réseau de neurone) At the HEIG-VD. Its goal is to classify different types of nuts. In order to achieve this goal, we decided to take several pictures of cashew nuts, hazelnuts, and pecans with various backgrounds, various specimens and various angles. Depending on the result, we will then eventually add pictures from the web.

We will use MobileNet V2, which is a pre-trained convolutionnal network. We will then add some layers and train them to our specific application.

Our application could be used for various purpose. For example, allow users to identify different nuts, for allergy purpose. This could also be used for industrial application when sorting nuts or detecting allergens in food or even better, an app on social media that tells you what sort of nut you are !

The problem

> describe what are the classes you are learning to detect using a CNN, describe the database you collected, show the number of images per class or a histogram of classes (is it a balanced or an unbalanced dataset? Small or big Data ?) and provide some examples showing the intra-class diversity and the apparent difficulty for providing a solution (inter-class similarity).

The problem is to be able to identify and differentiate between 3 sorts of nuts: pecan, hazelnuts and cashews, using a camera on a portable device.

Dataset and Data preparation

We took photos of the different nuts on various background (color, texture) with various angles and zoom without our smartphones. Our dataset consist of 587 images of pecans, cashews and hazlenuts. We were careful to take pictures that would represent the final condition best, that is, trying to identify a nut with a mobile device.

	path	label
0	dataset_train/cajoux/640x530.jpg	cajoux
1	dataset_train/cajoux/IMG_20220603_101340.jpg	cajoux
2	dataset_train/cajoux/IMG_20220603_101247.jpg	cajoux
3	dataset_train/cajoux/IMG_20220603_101124.jpg	cajoux
4	dataset_train/cajoux/IMG_20220603_104147.jpg	cajoux
...	...	...
583	dataset_train/pecan/IMG_20220610_104354.jpg	pecan
584	dataset_train/pecan/IMG_20220603_112530.jpg	pecan
585	dataset_train/pecan/IMG_20220603_112316.jpg	pecan
586	dataset_train/pecan/IMG_20220603_112445.jpg	pecan
587	dataset_train/pecan/IMG_20220610_104407.jpg	pecan

588 rows × 2 columns

Figure 1: Dataset Image List

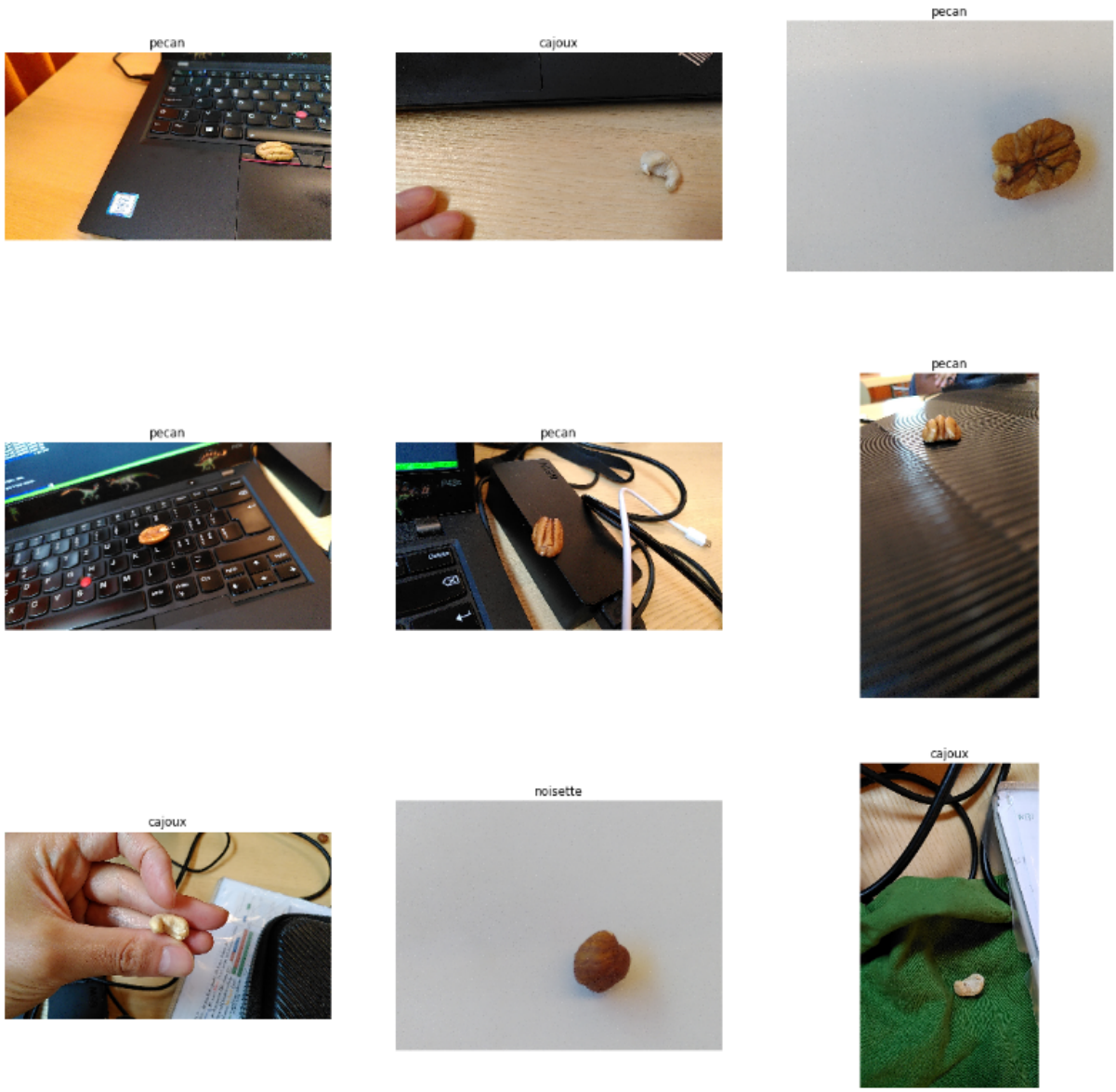

Figure 2: Sample of our dataset

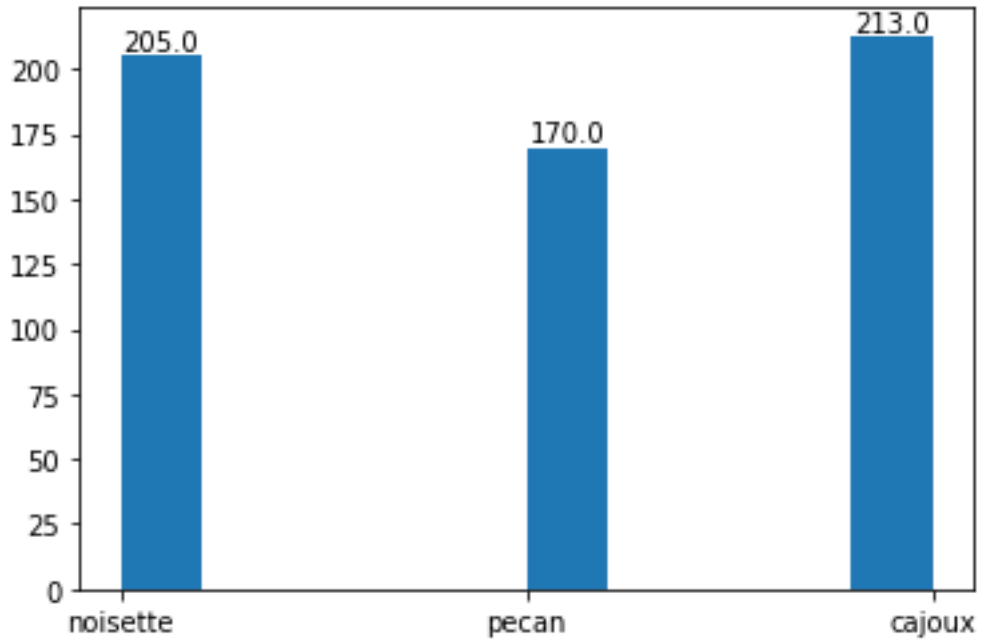

Figure 3: Dataset Histogram

We had to take more and more pictures because our first dataset had too much of the same background. Our final dataset consist of close-up pictures of the nuts with a “neutral” background so that our model can extract clear features plus more realistic picture taken at various angles and backgrounds so that it does not overfit and can work better in realistic conditions.

##TODO: data augmentation, crop, zoom, format, … Our whole images dataset is rescaled and resized in order to always give the same dimensions as input for our model. In order to have slightly different images at each iteration, we applied some data augmentations to our training set. It include RandomFlip, RandomZoom, RandomRotation and RandomContrast. We chose to use value between -0.2 and 0.3 and not higher because we saw that the resultant pictures were too deformed, and thus could maybe mislead our model.

> describe the pre-processing steps you needed (e.g., resizing, normalization, filtering of collected images, perhaps you discarded some data). Describe the train, validation and test datasets split.

Model creation

In order to find our model, we proceeded the same way as for all the precedent labs: trying something and then find tune until we get acceptable results (plot, confusion matrix, etc…).

We had issues finding the right model. Our results were sometimes good with the train set and validation set but then terrible with the app on the mobile device. It was also confusing to find the right parameters and layers configurations. Adding layer or neuron seemed to just make things worse, as did removing layers or neurons.

> a. What hyperparameters did you choose (nb epochs, optimizer, learning rate, ...) ?

> b. What is the architecture of your final model ? How many trainable parameters does it have?

> c. How did you perform the transfer learning ? Explain why did you use transfer learning, e.g., what is the advantage of using transfer learning for this problem and why it might help ?

Transfert learning is extremely valuable as it allows us to leverage the power of another model that is already trained. We are using MobileNet V2, a convolutional network optimised for mobile devices. The first layers are the pre-trained layers of MobileNet on top of which we add our layers which are the only one that are being trained. Transfer learning works because many layers do the same things on any model, that is, extracting low level features (for example edges), and medium level features (for example shapes) which are common to any images. Without transfer learning, we would have to train our model every time for this same task.

We tried a lot of different variation. We started with very simple architectures like a single layer of 20 neurons, 2 layers, 3 layers. We also tried 250 neurons, adding dropout, modifying out data augmentation but our model was still bad in realistic condition. With the previous labs, we were used to have very simple architectures and a small number of neurons but this task is much more complex. We searched the web for examples and common settings for image classification and found out that using thousands of neurons was more common for such a task. We tried adding 2 layers with 1024 neurons each and a third layer with 512 neurons. The graph of the results wasn't too good as you can see below, but our confusion seemed to indicate that the classification was ok.

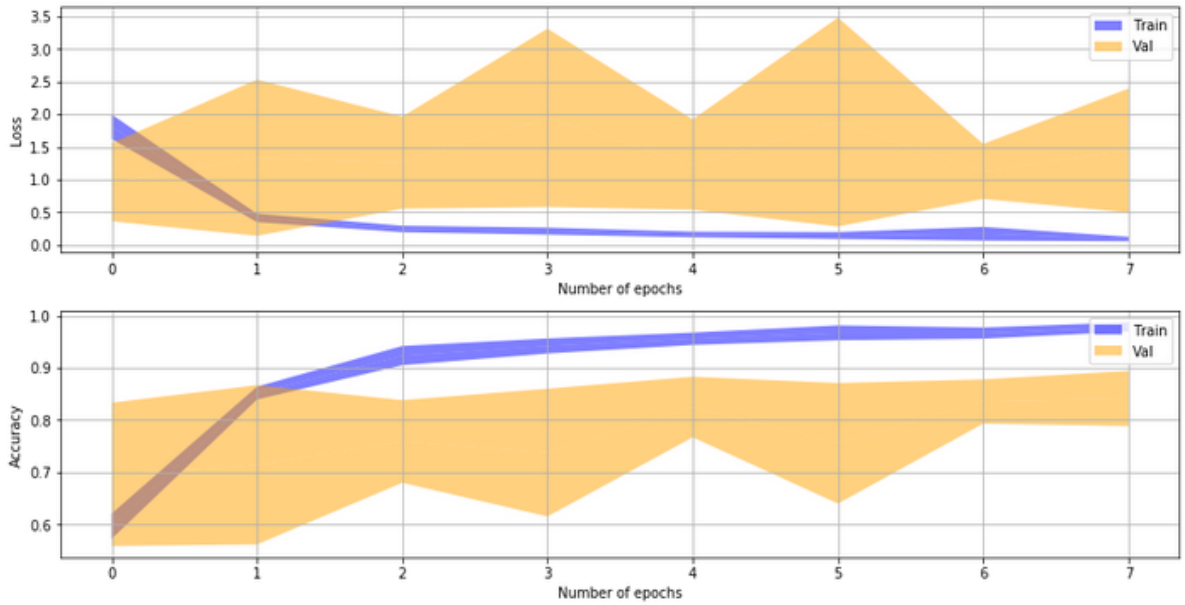

Figure 4: Result Graph

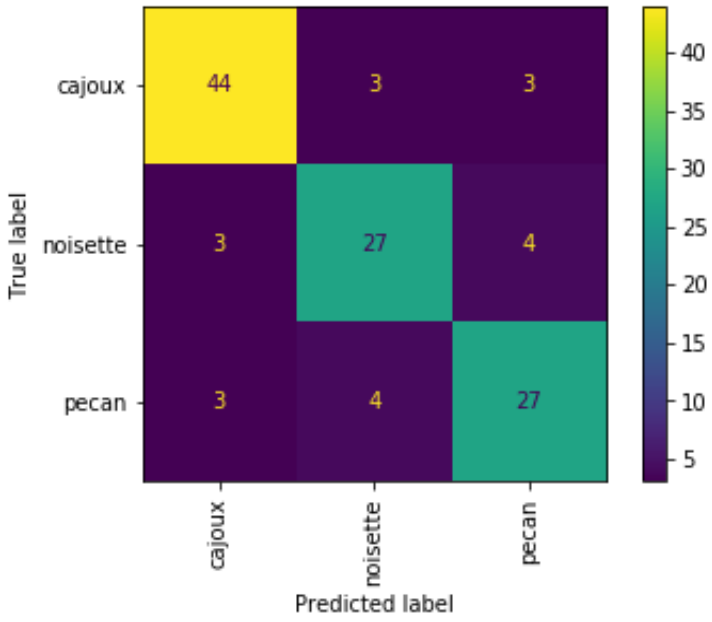

Figure 5: ConfusionMatrix

Our grad-cam also indicated that the model was able to find the nuts and was activated by them.

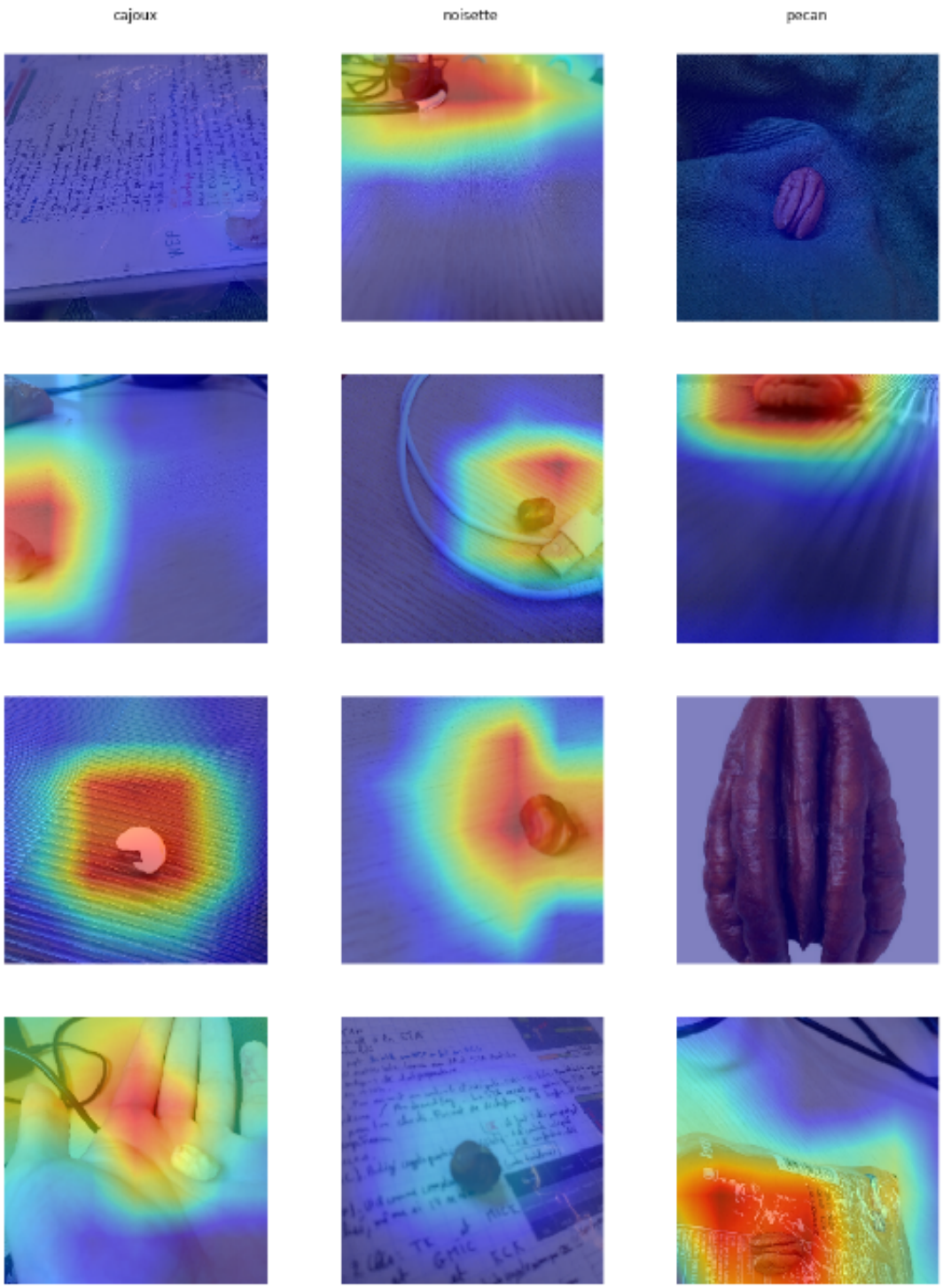

Figure 6: Grad Cam

So we loaded our model on our phones and tried in realistic conditions. It was the first time the results

were good using our phones.

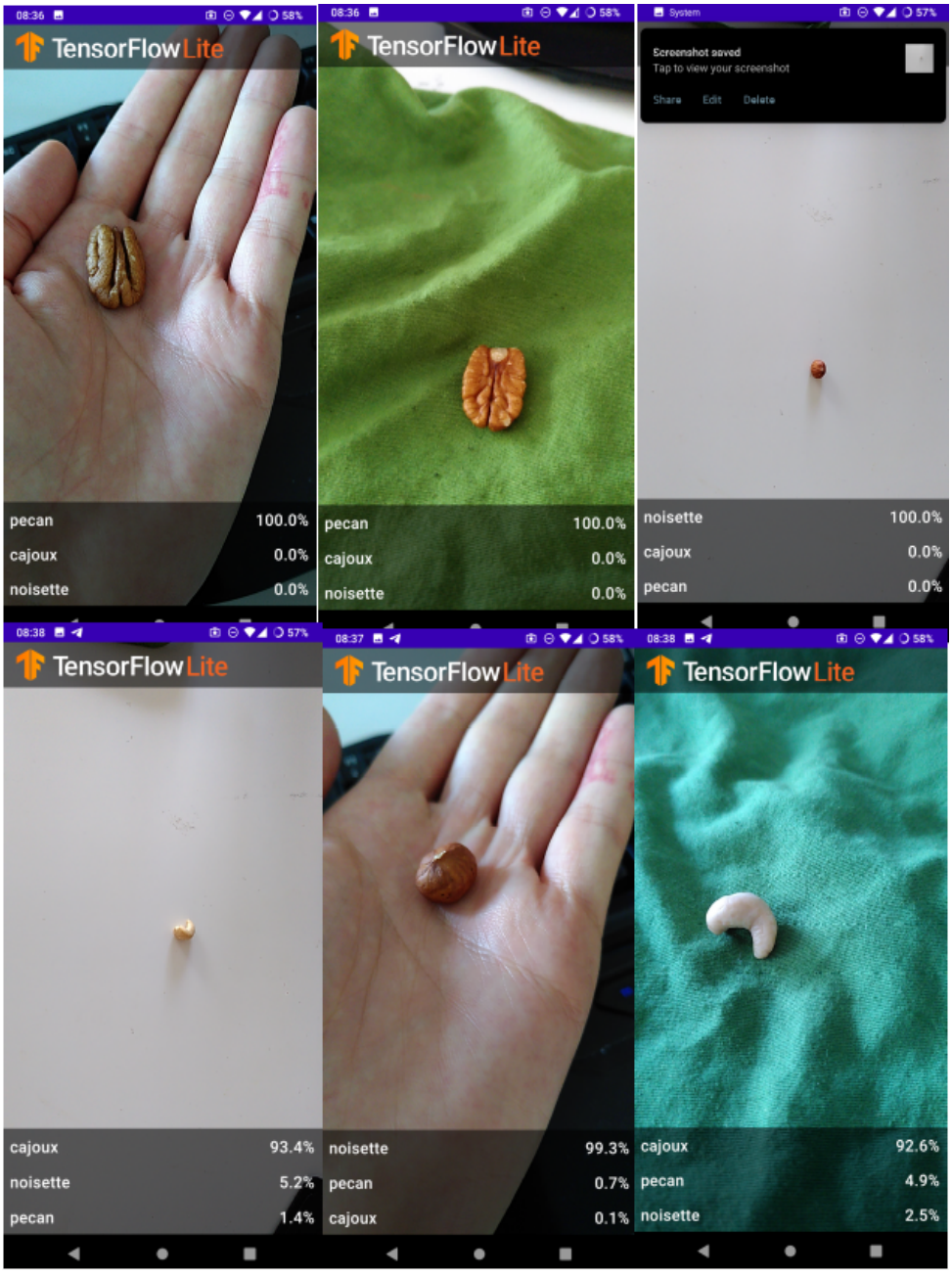

Figure 7: PhoneResults Good classification

Still, our model is very easy to trick by changing the angle or the background.

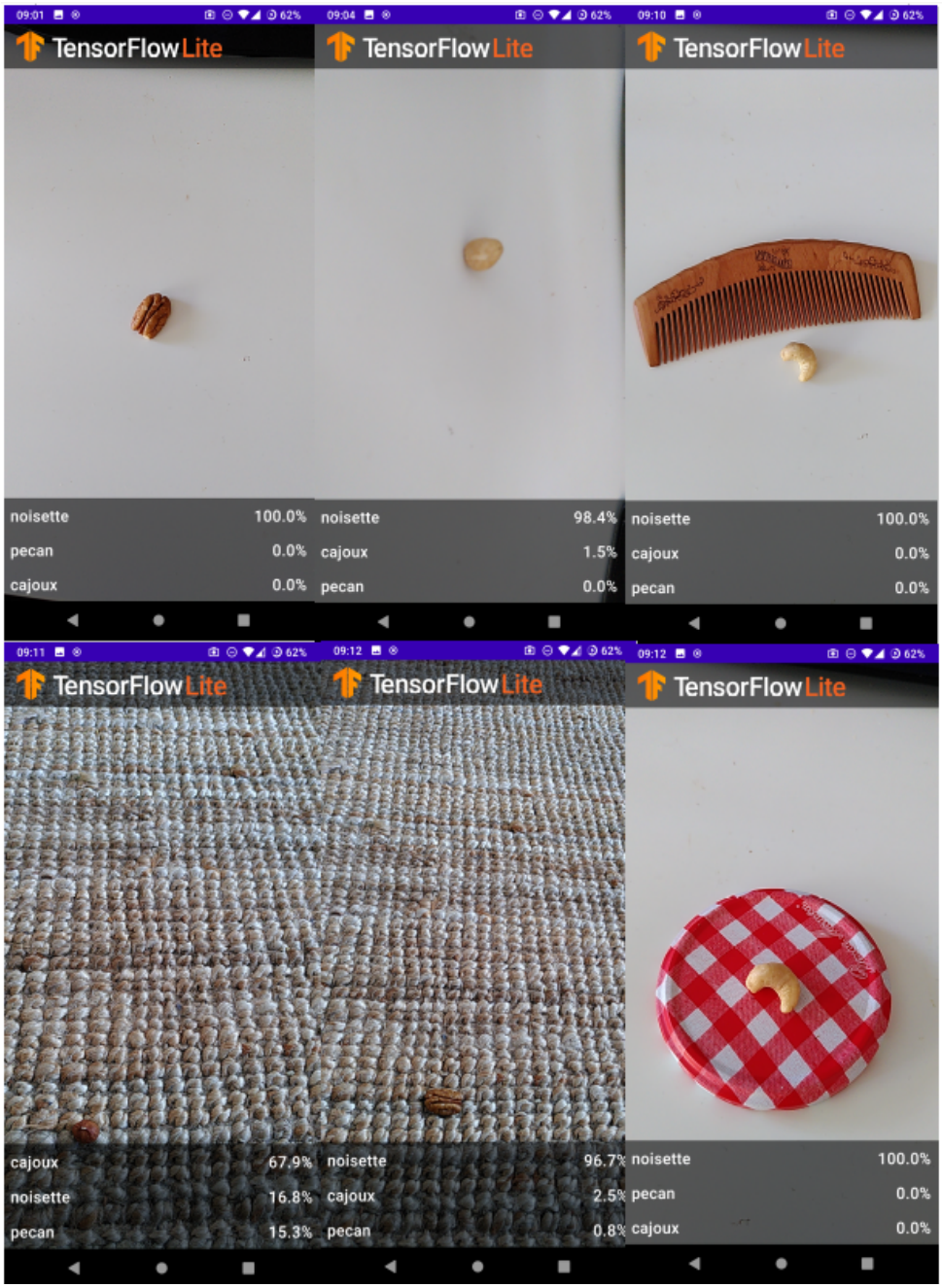

Figure 8: PhoneResults Bad classification

Parameters

Final model :

```
Total params: 5,145,667
Trainable params: 3,299,843
Non-trainable params: 1,845,824
```

Our final model consist of the frozen MobileNetV2 layers plus the 4th last layers we added :

- Dense(1024, activation="relu")
- Dense(1024, activation="relu")
- Dense(512, activation="relu"),
- Dense(len(LABEL_NAMES), activation="softmax")

Results

##TODO: screenshots, confusion matrix, etc

> a. Provide your plots and confusion matrices

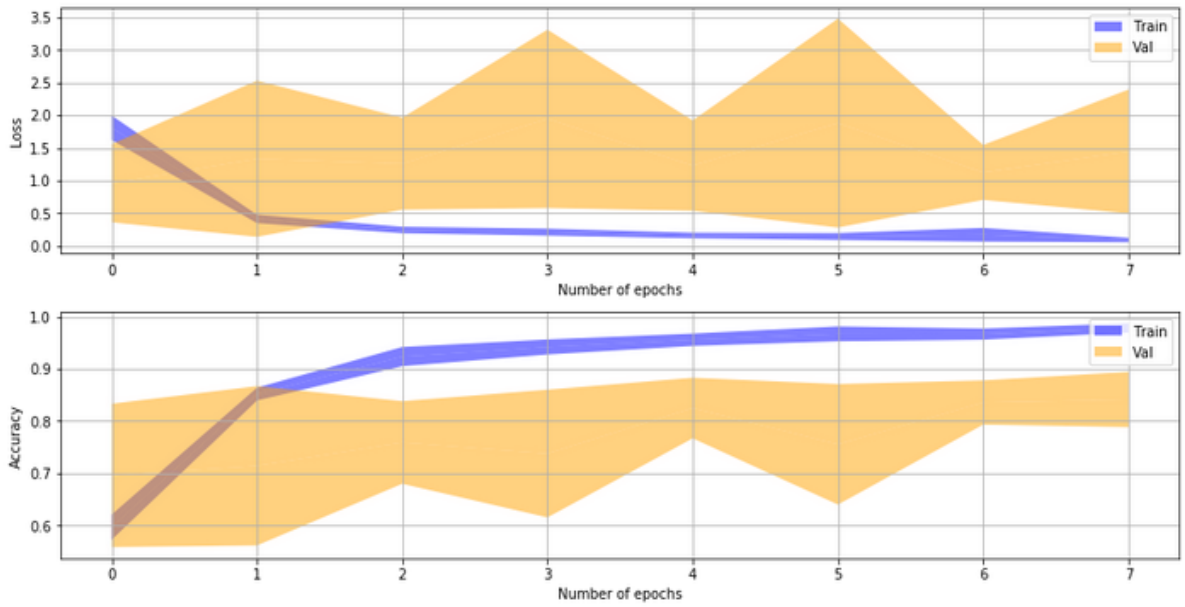

Figure 9: Result Graph

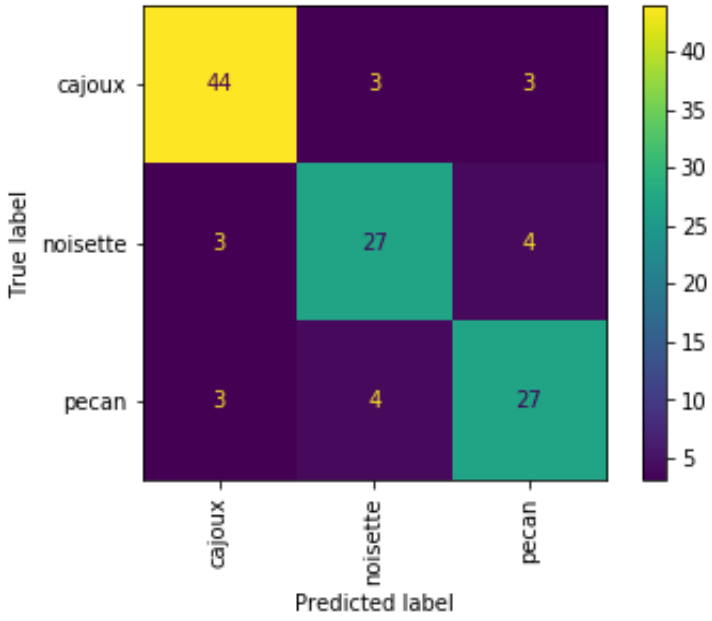

Figure 10: ConfusionMatrix

b. Provide the f-score you obtain for each of your classes.

c. Provide the results you have after evaluating your model on the test set. Comment if the performance on the test set is close to the validation performance. What about the performance of the system in the real world ?

d. Present an analysis of the relevance of the trained system using the Class Activation Map methods (grad-cam)

e. Provide some of your misclassified images (test set and real-world tests) and comment those errors.

f. Based on your results how could you improve your dataset ?

g. Observe which classes are confused. Does it surprise you? In your opinion, what can cause those confusions ? What happens when you use your embedded system to recognize objects that don’t belong to any classes in your dataset ? How does your system work if your object

> is placed in a different background ?

Conclusion

We tried several configurations for our model (1 layer, 2 layers, 3 layers, 256 neurons, 8 neurons, dropout, etc…) and most of the time, we managed to get high accuracies and fine confusion matrix. But even so, we had problems once our model loaded on the app. Indeed, the app detected each classes with great confidence, but not for the right nut. We believe that our model is too influenced by the background due to a to different images set between our 3 classes. TODO: ARN IS FUN

> finalize your report with some conclusions, summarize your results, mention the limits of your system and potential future work