Image Classification with Convolutional Neural Networks (CNNs)

EECE-4710 IoT and Machine Learning

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1. Objective

Investigate the use of Convolutional Neural Networks (CNNs) for Classification of images. Work with Fashion-MNIST dataset with fashion images.

2. Edge Impulse

This week, we get introduced to Edge Impulse (https://www.edgeimpulse.com/). Here are some of the statements that describe what Edge Impulse is:

>We put ML into real products.

>Edge Impulse is an integrated cloud environment that enables end-to-end development of AI/ML solutions for embedded products.

>Edge Impulse is the leading development platform for machine learning on edge devices, free for developers and trusted by enterprises.

>Edge Impulse provides the ultimate development experience for ML on embedded devices for sensors, audio, and computer vision, at scale. It enables the deployment of highly-optimized ML on hardware ranging from MCUs to CPUs and custom AI accelerators.

>Using Edge Impulse you can now quickly collect real-world sensor data, train ML models on this data in the cloud, and then deploy the model back to your Arduino device.

However, the best way to learn and understand Edge Impulse is to work an example in it.

3. Assignment

Example 1:
In this example, we do classification using CNNs. The CIFAR dataset has images with class_names = ['airplane', 'automobile', 'bird', 'cat', 'deer', 'dog', 'frog', 'horse', 'ship', 'truck']. You must work through this Jupyter Notebook, if you have not done it in class:
CNN_Cifar_10.ipynb

There is nothing to include in the written report about this example. You just have to do it for good practice. 😊

Example 2:
In this example (, we develop a CNN model to do classification of fashion images for 10 fashion categories. The assignment is inside the Jupyter Notebook:
W4_Assignment_CNN_FashionMNIST.ipynb

Start Colab, then, click on File->Upload Notebook and select from your computer the said Notebook. Once you uploaded the Notebook, do first Edit->Clear All Outputs. Then, work through all its code cells and follow the assignment tasks.

You will have to enter some values for some variables as you work trough the Notebook. Once you got that those right and run the whole Notebook successfully, you will have to re-run five more times – each time for different value combinations of hyperparameters of your choice. However, you should change those hyperparameters with the goal of improving model performance!

In addition, you must create a function to show any desired image from the dataset, together with their labels.

Example 3:
This is the Edge Impulse example. You must do it all, similarly how it was shown/started in class. Use the lecture slides (W4_2_*) as a guide as well, because they show screen-snapshots all most of these steps!

Here is a summary of the steps I did (some directory paths are specific to my own laptop):
---Created account on **Edge Impulse (EI)**
---Log in and create new project; call it "Cifar10 Classification (Reloaded) - Cats vs. Dogs"
---Downloaded ZIP of https://github.com/YoongiKim/CIFAR-10-images
Placed that in: M:\MARQUETTE\EECE4710_IoT_and_ML\sandbox_edgeimpulse\CIFAR-10-images-master
---In the new EI project click on Let's Collect Some Data --> Upload data
Create **dog** label and select to open and upload all 5000 images from:
M:\MARQUETTE\EECE4710_IoT_and_ML\sandbox_edgeimpulse\CIFAR-10-images-master\train\dog
Click on "Begin upload" button in EI.
It will take a minute or too to upload all 5000 dog images…
Then, repeat the above upload procedure for three more sources of images: **cat** train, and then **dog** and **cat** test.
After all that, inside EI, click on Training Data icon at the top. Then click on any of the images uploaded – you should see it displayed on right hand side.
---Next in project: Impulse Design --> Create an Impulse
Image data 32x32
Add a Processing Block, an Image
Add a Learning Block, a Classification (Keras), name it "NN Classifier"
Click on Save Impulse button.
---Next in project: Impulse Design --> Image
Color depth RGB
Then click Save Parameters, and then click Generate Features (schedules job in cluster…)
---Next in project: Impulse Design --> NN Classifier
Keep most settings.
Replace Dropout layer with Dense Layer with 64 neurons
Then, train model by clicking Start training. It will take a few minutes…
At the end, I got:
    Accuracy 71.2%
    Loss 0.56
    Flash usage 97.5K
    Model version: Quantized(int8)
---Next in project: jump to Model Testing
And click Classify All. Takes a minute or too…

At the end, I got:
Accuracy 61.75%
---Next in project: Jump to Deployment
Select Run your impulse directly --> Mobile Phone
Gives a QR code; scan and have the classifier on your phone.
Play with it, by using it on some cat and dog images from the Internet. It should work, most of the time… 😊
---Next in project: jump to Impulse design -> NN Classifier
And click the 3-dots icon next to Neural Network settings. Select Edit block locally.
This will download on your laptop:
ei-cifar10-classification-(reloaded)---cats-vs.-dogs-nn-classifier.zip
Open the archive and study it. You should be able to identify the model inside the Python code.

Example 4:
This is a Jupyter Notebook that shows what's under the hood of the Edge Impulse project from Example 3! You must also work through this Jupyter Notebook:
ei_cifar10_image_classification_nn_classifier_explained.ipynb

Note that in the first code block you will have to replace the `API_KEY`
And also change the following two lines:
    X = download_data('https://studio.edgeimpulse.com/v1/api/165504/training/8/x')
    Y = download_data('https://studio.edgeimpulse.com/v1/api/165504/training/8/y')
To use your own projectId and learnId inside the URL format:
    https://studio.edgeimpulse.com/v1/api/{projectId}/training/{learnId}/x

NOTES:
- You can get the API_KEY in your EI project Dashboard -> Keys.
- In the EI Dashboard of your project you will also find the {projectId}
- To get the {learnId}, in EI project click on Impulse->NN Classifier (or whatever your model is) and look at the http link. It could be for example: https://studio.edgeimpulse.com/studio/209281/learning/keras/5 case in which learnId=5.

4. Deliverables

You must write (typed) a report and upload it as a PDF file on D2L. The report should be named "**LastName_hw4.pdf**". The report should include the following sections:
1) Title + course info + your name
2) **Summary.** Describe in one paragraph what the objective of the assignment is.
3) **Exploring Different Hyperparameters.** Describe your experiments from Example 2 and how you went about changing hyperparameters. List the hyperparameters and their values that you investigated. Include all plots "loss vs. epoch" and all "confusion matrices" that you created in those five additional runs. Present a discussion in which you compare your results.
4) **Edge Impulse.** Describe in a paragraph what you did in Example 3. Include 4 different screen shots of your smart-phone with the Classifier at work. Test images of cats, dogs, and humans.
5) **Conclusion.** Present your conclusions and describe what issues you encountered and how you solved them.
6) **References.** Include all references that you used, as a numbered list. Cite them in the report itself; do not just list them here.