UNIVERSIDADE DA CORUÑA USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA UniversidadeVigo

Deep Learning (Master's degree in AI)

Practice 1 - CNNs (2024-2025)

INSTRUCTIONS:

- **Deadlines:**
  - Part 1 - Custom CNNs: March 06, 23:59.
  - Part 2 - Pretrained CNNs: March 20, 15:30 (just before starting the RNNs practice).
- **Objectives**
  - In this practice we will develop several convolutional neural networks (CNNs) models trying to solve the classification problem posed by the CIFAR100 dataset.
- **Dataset**
  - The CIFAR-100 dataset is a collection of 60,000 color images (32x32 pixels) divided into 100 classes, with 600 images per class.
  - Each image belongs to one of 20 superclasses, grouping similar categories together. We will try to classify these superclasses.
  - The dataset is split into 50,000 training images and 10,000 test images.
  - In Figure 1 you can see several examples of the different images of the dataset.
  - In Table 1 you can see the different superclasses and classes of the dataset.
  - The dataset can be downloaded directly from Keras (`https://keras.io/api/datasets/cifar100/`). In the "`coarse`" the output labels are the coarse-grained superclasses.
  - The original dataset can be found here: `https://www.cs.toronto.edu/~kriz/cifar.html`.
- **Part 1: Custom CNNs**
  1. **Preprocess the dataset**.
     - Perform other preprocessing techniques such as standardizing image size, transforming the labels to categorical, normalizing the values, etc.
     - Create a validation dataset from the training dataset for hyperparameter tunning.

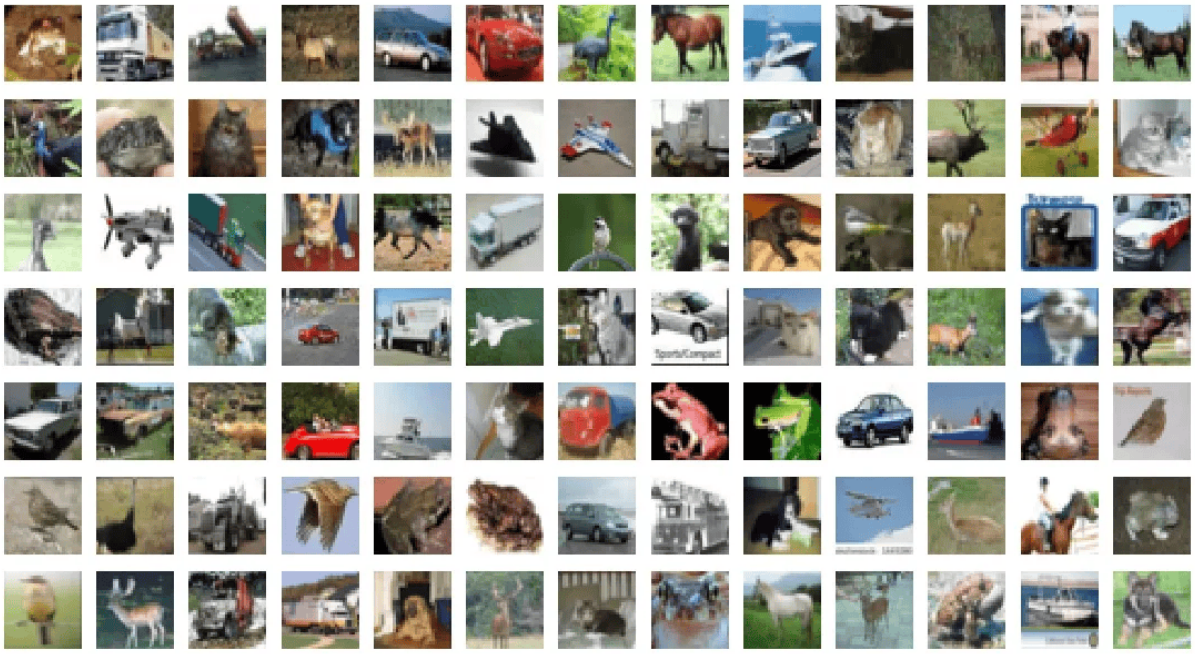

Figure 1: CIFAR100 examples

Superclass	**Classes**
Aquatic mammals	beaver, dolphin, otter, seal, whale
Fish	aquarium fish, flatfish, ray, shark, trout
Flowers	orchids, poppies, roses, sunflowers, tulips
Food containers	bottles, bowls, cans, cups, plates
Fruit and vegetables	apples, mushrooms, oranges, pears, sweet peppers
Household electrical devices	clock, computer keyboard, lamp, telephone, television
Household furniture	bed, chair, couch, table, wardrobe
Insects	bee, beetle, butterfly, caterpillar, cockroach
Large carnivores	bear, leopard, lion, tiger, wolf
Large man-made outdoor things	bridge, castle, house, road, skyscraper
Large natural outdoor scenes	cloud, forest, mountain, plain, sea
Large omnivores and herbivores	camel, cattle, chimpanzee, elephant, kangaroo
Medium-sized mammals	fox, porcupine, possum, raccoon, skunk
Non-insect invertebrates	crab, lobster, snail, spider, worm
People	baby, boy, girl, man, woman
Reptiles	crocodile, dinosaur, lizard, snake, turtle
Small mammals	hamster, mouse, rabbit, shrew, squirrel
Trees	maple, oak, palm, pine, willow
Vehicles 1	bicycle, bus, motorcycle, pickup truck, train
Vehicles 2	lawn-mower, rocket, streetcar, tank, tractor

Table 1: CIFAR100 superclasses and corresponding classes

2. **Develop a custom convolutional model for the classification problem.**
   - Do not use pretrained models or models already created in external libraries for this part.

- Determine the best architecture of the model (convolutional layers, pooling layers, number of filters, size of kernels, etc.).
- Use the validation dataset for hyperparameter tunning and avoid overfitting regularizing the model if necessary (data augmentation, dropout, weight regularization, etc.).
- Consider the use of deeper and more complex models such as Residual, Inception or Xception networks.

3. **Compare the results**.
   - Comment the results of each model developed.
   - Made a reasoned comparison of all the results obtained.
   - Comment advantages, disadvantages of the different approaches and elements of interests.
   - Summarize the final results in a table or graph.

- **Part 2: Pretrained CNNs**

1. **Use pretrained models**.
   - Test several pretrained models on the CIFAR100 dataset.
   - You can easily obtain them from the Keras applications (`https://keras.io/api/applications/`), but you can use different ones if you want.
   - Decide the best strategy for this type of models: feature extraction and/or fine tunning.
2. **Compare the results**.
   - Comment the results of each pretrained model and strategy used.
   - Made a reasoned comparison of all the results obtained.
   - Comment advantages, disadvantages of the different approaches and elements of interests.
   - Summarize the final results in a table or graph.

- **Practice groups**
  - The practice will preferably be done in pairs (it can be done also alone) and both members of the group will be responsible and should know everything that is delivered on their behalf.
  - No change of practice group will be made during the course. The group can be undone but its members will continue to carry out the practices alone.

- **Submission**
  - The exercises will be developed using Jupyter Notebooks.
  - Create one or several notebooks to carry out the different tasks.
  - Be organized when naming notebooks and notebook sections (using Markdown headings).
  - **Each notebook should include**:
    * The first cell of each notebook must be the full names of the authors.

    - The code for each of the models developed should be included and it should be a complete ML process: data loading and manipulation, network creation, training and results.
    - The notebook will be saved with the results of its execution included.
    - The code shall be accompanied by text cells with an explanatory report containing a description of the process followed, detailing the problems encountered and justifying the decisions taken.
  - **Submission process**
    - If you have several notebooks put all of them together in a ZIP file prior submission.
    - The exercises will be submitted using the virtual campus of each university:
      - Universidade da Coruña: `https://udconline.udc.gal/`
      - Universidade de Vigo: `https://moovi.uvigo.gal/`
      - Universidade de Santiago de Compostela: `https://cv.usc.es/`
    - Each member of the practice group must submit the notebook in their corresponding Moodle task. It is better to have a copy rather than an undelivered work.
    - There is a strict deadline for each assignment. Past due submissions will be rejected.

- **Evaluation criteria (for the two parts)**
  - Quality of the classifications obtained.
    - Classification accuracy on the test set of the custom model and of the pretrained ones.
    - Do not discard intermediate models, show us the different alternatives that you have been trying to reach the best final model, at least the most relevant ones.
  - Quality of the design.
    - The custom network design follows the recommendations on how to create the different types of convolutional networks.
    - Different types of convolutional layers (Residual, Wide) are tested and used.
    - The regularization techniques are correctly applied and a thorough analysis has been made to see which ones work best.
    - In pretrained networks use both feature engineering and fine tunning in a reasonable way.
  - Quality of explanations:
    - The process is sufficiently detailed and the decisions taken are justified.
    - The results are commented and interpreted correctly.
    - All the results are compared and summarized in a table.