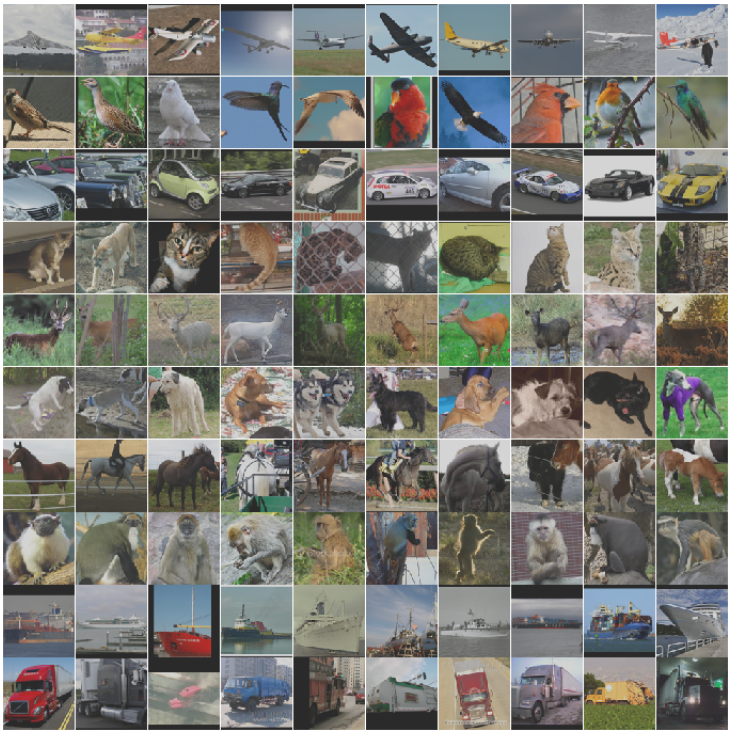
UNIVERSIDADE DA CORUÑA USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA Universidade Vigo

Deep Learning (Master's degree in AI)

Practice 1 - CNNs (2025-2026)

INSTRUCTIONS:

- **Deadline:**
  - March 26, 23:59.
- **Objectives**
  - In this practice we will develop several convolutional neural networks (CNNs) models trying to solve the classification problem posed by the STL-10 dataset.
- **Dataset**
  - STL-10 (`https://ai.stanford.edu/%7Eacoates/stl10/`) contains 13,000 labeled images of 96×96 pixels in color (5,000 for training and 8,000 for testing). It also includes 100,000 additional untagged images for unsupervised learning.
  - The images belong to the 10 possible categories shown in the following figure (airplane, bird, car, cat, deer, dog, horse, monkey, ship, truck) and are perfectly distributed (500 training images and 800 test images per class).



- **Part 1: Custom CNNs**

  1. **Preprocess the dataset**.
     - The dataset is included in TensorFlow datasets, so it can be easily downloaded from there (see `https://www.tensorflow.org/datasets/catalog/stl10`).
     - You have to perform some preprocessing techniques such as standardizing image size, transforming the labels to categorical, normalizing the values, etc.
     - You need to create a validation dataset from the training dataset for hyperparameter tunning.
  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, where they have improved, worsened, etc.
     - 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 dataset.
     - You can easily obtain them from the Keras applications (`https://keras.io/api/applications/`), but you can use different ones if you want.
     - Test several strategies for this type of models: feature extraction, fine tunning, etc.
  2. **Compare the results**.
     - Comment the results of each pretrained model and strategy used.
     - Made a reasoned comparison of all the results obtained and how they compare between them and with the custom CNNs developed.
     - 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 (use numbers to describe order) 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 should be commented and shall be accompanied by jupyter 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/`
    * The upload into the Moodle task is individual, so it can be done by either of the two group members, or by both if you want redundancy (in which case, make sure you upload the same thing).
    * 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.