SUPERVISED AND EXPERIENTIAL LEARNING
(Master in Artificial Intelligence, UPC-URV-UB)

Spring semester, Course 2021/2022
April 7th, 2022

Practical Work 2 (PW2, Individual): *Combining multiple classifiers*

The objective of this exercise is to implement, compare and validate two combinations of multiple classifiers: *a random forest* and *a decision forest*.
The implemented *Random Forest* [Breiman, 2001] and *Decision Forest* [Ho, 1998] will be compared and evaluated in several domains. The main steps that students must undertake are listed below.

Procedure

1. *Implement a Random Forest* and *a Decision Forest technique* in your selected programming language (Java, C++, R, Python, etc.). The *base-learner* for inducing the trees will be the CART method.
    a. Both *the Random Forest (RF)* and *the Decision Forest (DF) classifier must be able to read a* dataset in csv file format
    b. Then, they should *learn the model (the random forest or decision forest)* from the training data set, and at the same time *produce an ordered list of the features* used in the forest, according to its importance. The importance can be estimated as the frequency of its appearance in the random forest/random decision constructed.
    c. *The models must have, at least, the hyper-parameter F (number of random features used in the splitting of the nodes in RF or in each tree in DF) and the number of trees (NT) desired.*
2. *Implement a forest interpreter* that given a *random forest* or a *decision forest* would be able to classify a test dataset, obtaining the corresponding classification accuracy values (or generalization error) for different combination of values of *F* and *NT*. For instance, try (when make sense), being *M* the total number of features:

    Random Forest
    - Each training set for each tree **is a bootstrapped sampling of the original training set**
    - *NT = 1, 10, 25, 50, 75, 100*
    - *F = 1, 3,* $int(\log_2 M + 1)$, $\sqrt{M}$

    Decision Forest
    - Each training set for each tree is the **same original training set**
    - *NT = 1, 10, 25, 50, 75, 100*
    - *F =* $int(^M/_4)$, $int(^M/_2)$, $int(^{3\,*\,M}/_4)$, $Runif\,(1,M)$ for each tree

Where *Runif(1,M)* is a function generating a pseudorandom integer value, *ru*, such that $1 \leq ru \leq M$ with a uniform distribution probability.

Note that the **first three values** of *F* in the *Decision Forest* are constant for all trees of the forest, but the **fourth value** is different for each tree in the forest.

3. *Evaluate both classifier models obtained in at least 3 databases* (one small, one medium and one large). You can use databases from UCI ML repository or other sources. Small ≈ (# instances ≤ 500), Medium ≈ (500 < # instances ≤ 2000), and Large ≈ (# instances > 2000). Obtain a summary table with the classification results (accuracy/error) and an ordered list of features for the 3 databases and the different combination of hyper-parameters.

Deliverable

A **ZIP file** labelled as "**PW2-SEL-2122-NameSurname**", delivered **through** "**Racó de la FIB**" (in the "Practical" tab) with the following content:

1. A folder named "**Documentation**" with a report (**maximum 15 pages on 11 pt. letter size) containing:**
    a. Pseudo-code of *your implemented algorithms* of the *random forest* and the *decision forest* technique
    b. *Evaluation of results* for both algorithms and for all the tested databases:
        i. Table with the accuracy/error results for the different combination of hyper-parameters, and adequate comments.
        ii. Ordered list of features (relevance) resulting from the different combination of hyper-parameters, and adequate comments.
    c. Instructions on how to execute the code
    d. Other comments
2. A folder named "**Data**" with the files with the original dataset/s or database/s used both for training and for testing.
3. A folder named "**Source**" containing the source code of the implementation
4. An **executable object file** (*.jar, etc.) if available
5. A **README.txt file** specifying the structure and contents of the ZIP file

Students must deliver the ZIP file on **12/5/2022**.

Qualification

The qualification of this work will take into account the quality/functionality of the software delivered (correctness, efficiency and scalability), the robustness of the code, and the written documentation delivered.

References

[Ho, 1998] Tin Kam Ho. The Random Subspace Method for Constructing Decision Forests. *IEEE Transactions on Pattern Analysis and Machine Intelligence* 20(8):832-844, 1998.

[Breiman, 2001] Leo Breiman. Random Forests. *Machine Learning* 45:5-32, 2001

PW2 is due on May 12th, 2022