LELEC2870 Project

Airfoil noise prediction

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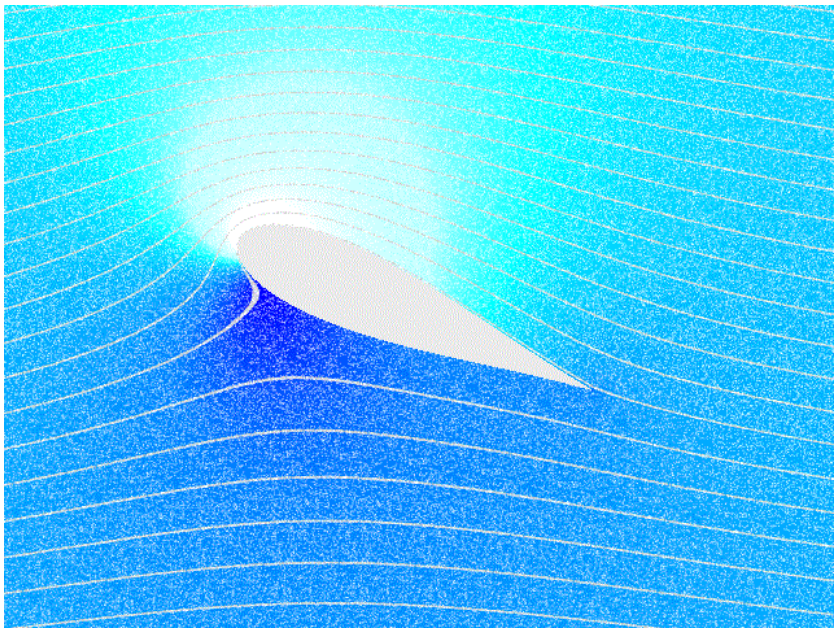

Introduction

The noise generated by an aircraft is an efficiency and environmental issue for the aerospace industry. A component of the total airframe noise is the self-noise of the airfoil itself; this is defined as the noise generated when the airfoil passes through smooth non-turbulent inflow conditions. The noise is generated through an interaction of the airfoil with its own boundary layer and/or the near wake region.

There have been various modeling attempts to predict the noise of an airfoil. Acoustics and aerodynamics models proved to be long to compute and less accurate than empirical models. In this project, you will build an empirical noise model based on 1000 tested airfoils.

Instructions

Model

You will build regression models that predict airfoil noise based on a few features. You can use any of the methods seen during the lectures. We expect you to, at least, implement linear regression, KNN[1] and one other non-linear method. Features selection and model selection shall also be part of your work. Pay attention to the fact that the model selection can require a lot of computation time. You are advised to explore the metaparameters space according to the time available.

Prediction

Once your model is properly selected and validated, you are asked to produce predictions Y2 on the data X2 for which we have kept secret the corresponding targets. Your prediction quality criteria shall be the root mean squared (rms) error. In addition, you will provide an estimate of the rms error that you expect on your prediction.

[1]K-Nearest Neighbour : Regression model with metaparameter K that predicts the output of a sample as the mean of output of the K nearest neighbours in the features space.

Report

You will produce a report documenting your technical choices and experimental results. We do not need a course on the methods you use. We are more interested in what you did and why. Try to illustrate your results by graphics (with legends) and comment them. Be critical about what you observe and try to give a possible justification of the obtained results. Summarize your results and observations in a conclusion. A strict maximum of 7 pages (font of size 11 or larger) will be observed. Annexes might be included in the digital version only. Plastic covers and bindings are not required (a paper clip or a staple will do).

The report will be the basis of a discussion which will take place during the exam session. The main objective of your report will be to convince the reader of three things :

1. that you selected the best model with the best hyper-parameters for the predictions on the second dataset
2. that you applied a proper methodology to assess the accuracy level of your predictions
3. that you discussed the features impact on the output.

You will work by group of two or alone on the provided dataset. All your figures and computation need to be reproducible by us running your implementation code on the provided data (please make your code as clean and documented as possible).

Data

On the course website, you will find a mat file containing the following variables :

- X1 : Instance-feature matrix for which targets are known
- X2 : Instance-feature matrix for which targets are not known
- T1 : Targets corresponding to X1 instances (Scaled sound pressure level, in decibels).
- feature_names : The 8 feature names
- target_name : The name of the target

Each row in the data corresponds to an instance (an airfoil profile). Each column represents one of the features listed here :

1. chord length (cl, in meters)
2. angle of attack (aa, in degrees)
3. manufacturer (m, two manufacturer)
4. Side thickness (st, in meters)
5. normalised roughness coefficient (r)
6. free-stream velocity(fsv, in meters per second)
7. noise frequency (f, in Hertz)
8. noise period (p, in seconds)

Programming languages

The programming language you will use is up to you but we strongly recommend Matlab, Python or R. The best language to use here is the one you already master the most. As we may run your code, please specify where your toolboxes and packages come from.

For matlab users, the Netlab toolbox that is on the moodle website can be used for MLP regression.

R users can use all the packages they can get with "`install.packages`" commands.

Python users can use all the packages they can get with "`pip`" commands.

Agenda

As soon as possible :

- Register your group on the form that is linked from the course website.

Thursday November the 30th and Thursday December the 14th at 4:15pm

- We will be available in the lecture room to answer your questions.

Thursday December the 21st, 1 p.m

- submit your work as an archive (.zip) containing the following items
  - Your report (pdf)
  - A mat file called "predictions.mat" and containing two variables : Y2 (corresponding to your predictions on X2) and ermse (corresponding to your expected rms error).
  - A folder containing all scripts you wrote for the project.
- In addition, you will provide two paper copies of your report (no fancy cover required!) to be left in front of the assistants' office (Maxwell a.138).

Evaluation Criteria

- Respect of the instructions and deadlines
- Quality of the report and its defense (discussion)
- Proper validation of your model(s)
- Consistency between the report, your implementation and your prediction
- reproducibility of your results

Tips

Here is a list of advices for the project.

Before you start to code:

- Get familiar with the toolboxes.
- Pay attention to avoid unnecessary loops: MATLAB works better when an operation is expressed in matrix form. You also should remove all operation which could be done outside of the loops.

Before any analysis:

- A fast univariate analysis of the data is always useful.

- Normalise your data if necessary.
- Some outliers might be excluded from the learning set (if you decide to remove some observations, explain why you removed them).

Before you send us the report:

- Make sure that each choice is justified, each result is commented and interpreted; each graph should have a legend.
- Comment your model performances.
- You can discuss the project with other students, in fact, it is a great idea ! You could compare your results and those obtained by other groups, but remember that it is not allowed to copy what other did...

We will be happy to answer during the Q/A sessions or on appointment. Good luck !