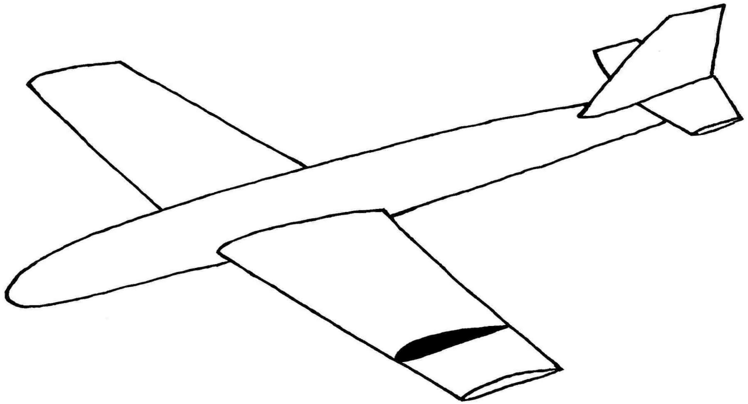
ME674
Soft Computing

Artificial Neural Network (ANN) Project

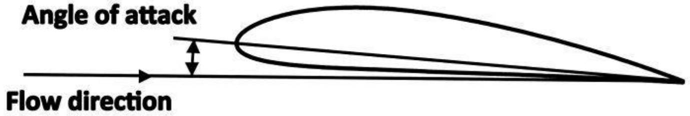
Kuldeep Singh
234103005
Aerodynamics and Propulsion

Dataset Selection

- NASA Airfoil Self-Noise Dataset
- Airfoil is the cross section of an Aircraft Wing



Scientastic (scientastic69.blogspot.com)

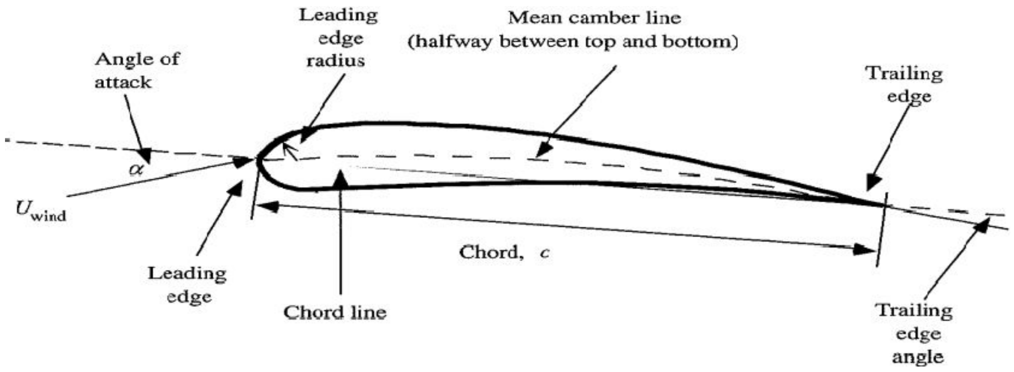


Architecture Myths #22: Biomimesis – misfits' architecture (misfitsarchitecture.com)

About Dataset

- NASA dataset obtained from a series of aerodynamic and acoustic tests of two and three-dimensional airfoil blade sections conducted in an anechoic wind tunnel.
- The NASA data set comprises different size NACA 0012 airfoils at various wind tunnel speeds and angles of attack. The span of the airfoil and the observer position were the same in all of the experiments.

Attribute Information



[Experimental Study on Modal and Harmonic Analysis of Small Wind Turbine Blades Using NACA 63-415 Aerofoil Cross-Section | Semantic Scholar]

Input / Features

1. Frequency (f) in Hertz, Hz
2. Angle of Attack (α) in Degrees
3. Chord Length (c) in metres
4. Free Stream Velocity (U_∞) in m/s
5. Suction Side Displacement Thickness (δ) in metres

Output / labels

- Scaled Sound Pressure Level (SSPL) in dB (decibel)

Transfer Function Selection

- SSPL values are not binary therefore, possibility of using “Hard limit transfer function” goes to zero.
- By looking at the SSPL values, these are not changing LINEARLY. Therefore, possibility of using “Linear or Piecewise Linear Transfer Function or RELU” becomes zero.
- Also, values of SSPL are POSITIVE. Therefore, I can not use “tan-sigmoid transfer function”. As its value belong to [-1,1]
- Now, I am left with “log-sigmoid transfer function”. Its value lies in [0,1] but values of SSPL are GREATER than 1.
- Therefore, I NORMALISED the DATASET.

Normalising Dataset

Normalising Equation

$$\frac{X^{Norm} - a}{b - a} = \frac{V - X^{Min}}{X^{Max} - X^{Min}}$$

Where, X^{Norm} = normalised value of X

V = value to be normalised

X^{Min} = Minimum value of X in the Dataset

X^{Max} = Maximum value of X in the Dataset

For log-sigmoid transfer function, I am considering range in which normalised values should lie i.e. [0.1,0.9] = [a,b] => a=0.1 and b = 0.9

Connection weights and Biases Initialisation

- As a thumb rule initial guess for the CONNECTION WEIGHTS and BIASES should belong to [-1,1]
- Generating Uniformly Distributed Random Floats between [-1,1] using python random module i.e. random.uniform(-1,1)

Mode of Training of Neural Network

- We know BATCH MODE of training is more accurate than SEQUENTIAL MODE.
- Therefore, adopting BATCH MODE of training to Train the network.

Methodology

Taking inputs from the USER:

1. Number of Input Neurons
2. Number of Output Neurons
3. Number of Training Patterns
4. Number of Testing Patterns

- Number of Hidden Layer = 1
- Optimal Number of Hidden Neurons are finding based on MSE

Optimal Number of Hidden Layers and Hidden Neurons

Base on the MEAN SQUARE ERROR (MSE) after every iteration.

$$MSE = (1/2p) * \Sigma_p (T^{(p)}_{ok} - O^{(p)}_{ok})^2$$

Where, $T^{(p)}_{ok}$ is the Target value of k-th output neuron for p-th pattern

$O^{(p)}_{ok}$ is the Target value of k-th output neuron for p-th pattern

Learning Rate (η)

To make balance between Convergence and Stability of the program, a moderate value for η has been chosen i.e.

$$\eta = 0.6$$