Fast Symmetry Detection with Deep Learning and GeConv

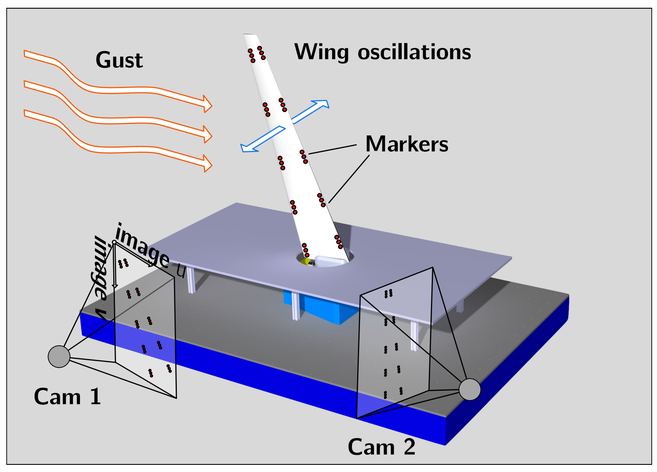
PhD Candidate: T. Mkhoyan
Department: ASM
Supervisor 1st: Dr.ir.R. De Breuker
Supervisor 2nd: Dr.ir.C.Visser
Promotor Dr.ir.R. De Breuker
Contact: T.mkhoyan@tudelft.nl

Aim

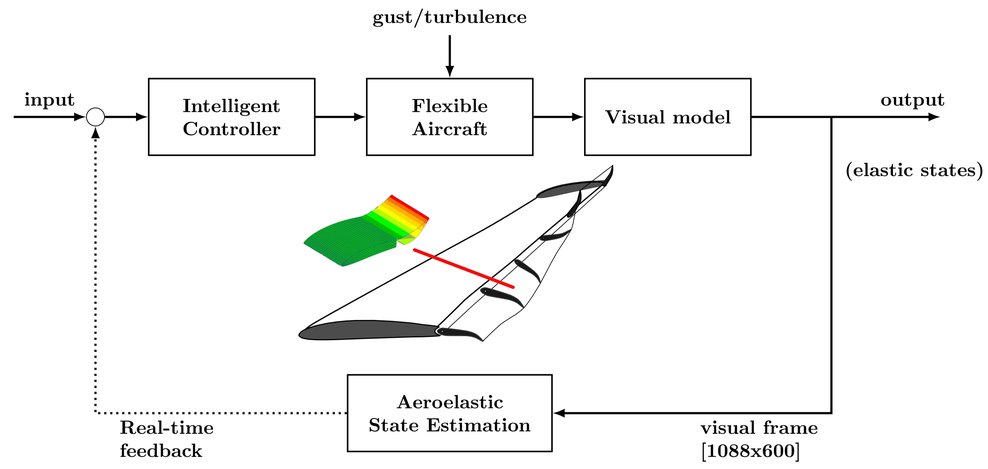
This study: Develop Fast 2-axis reflectional symmetry detection routine for estimation of aircraft wing orientation. Two methods developed and compared: traditional computer vision (*GeConv*) versus pure Deep learning (*RotNet*).

High level: Robust machine learning pipeline for prediction of wing deflection for aeroservoelastic control from raw images.

The Experiment

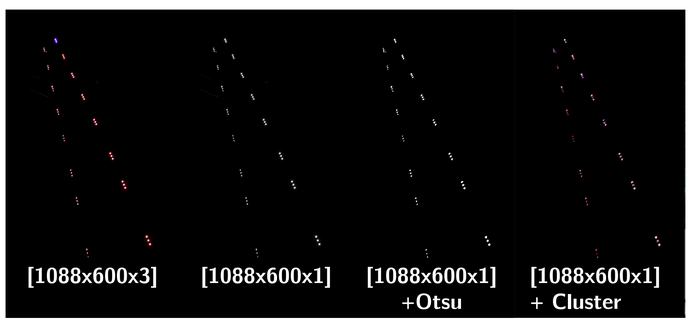


Visual based model-free control



GeConv

Image filters and clustering (DBSCAN):



Sort and rotate points:

$$\mathbf{P}_{\theta hull} = sort(\mathbf{P}, sort(\boldsymbol{\theta}_{cp_k})); \ \mathbf{R} = \begin{bmatrix} \cos(\theta_k) & -sin(\theta_k) \\ \sin(\theta_k) & cos(\theta_k) \end{bmatrix}$$

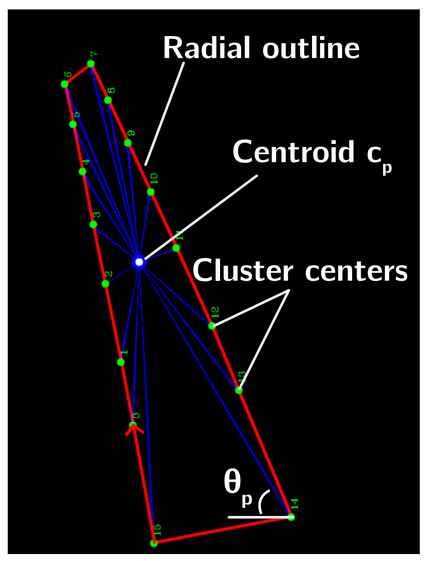
Geometric convolution and symmetry score:

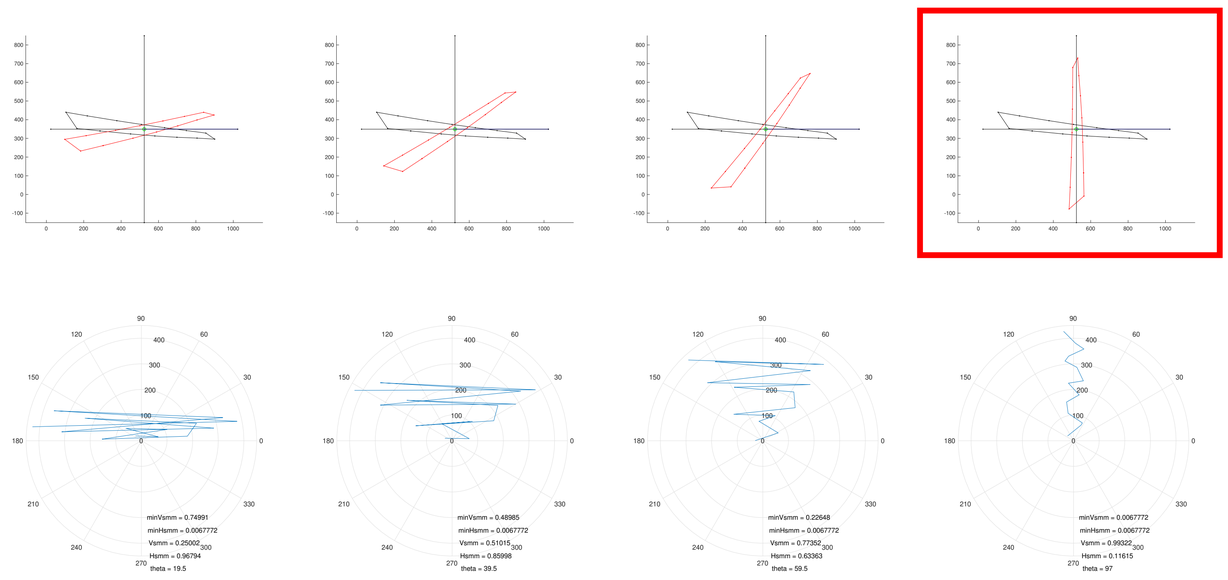
$$\mathbf{P}_{\theta_k} = (\mathbf{R} \cdot (\boldsymbol{\theta}_{\mathbf{k-1}} - \boldsymbol{\theta}_{cp})^T)^T + \boldsymbol{\theta}_{cp}$$

$$\theta_{Vsymm} = min(|mean(|\sin(|\boldsymbol{\theta}_{k_{cp}}|)|), \theta_{Vsymm})$$
$$\theta_{Hsymm} = min(|mean(|\cos(|\boldsymbol{\theta}_{k_{cp}}|)|), \theta_{Hsymm})$$

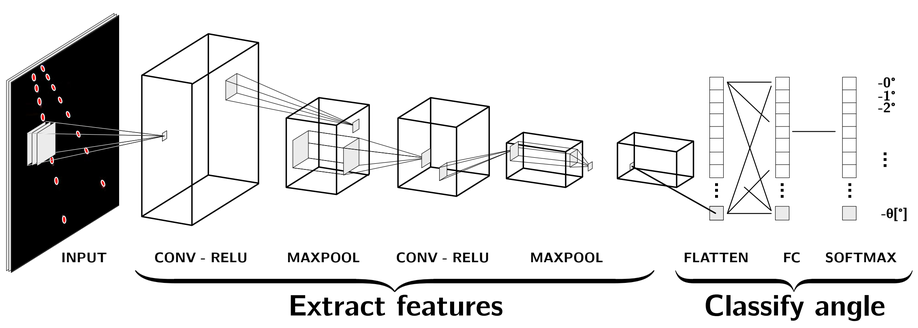
GeConv: Geometric Convolution process

Input [1088x600x3] → HSV-BW [1088x600x3] → BW img [1088x600x1] → Contours [1088x600x1] → Cluster [1088x600x1]

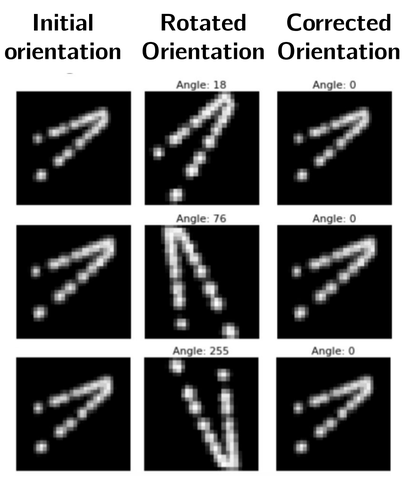


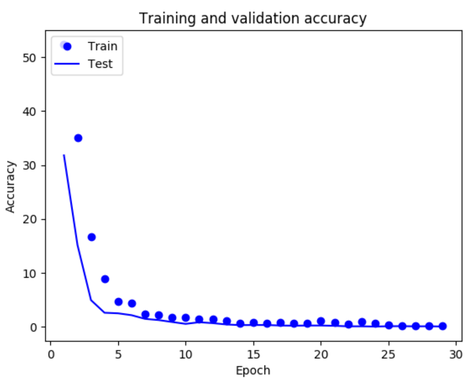


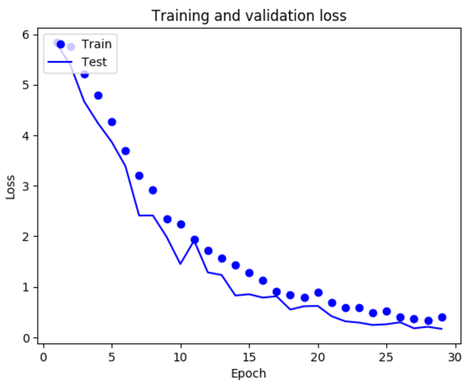
DCNN structure



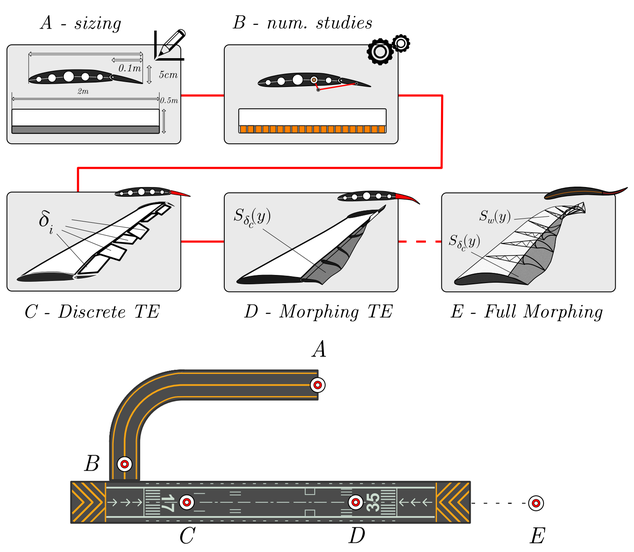
DCNN: training Deep Convolutional Neural Network



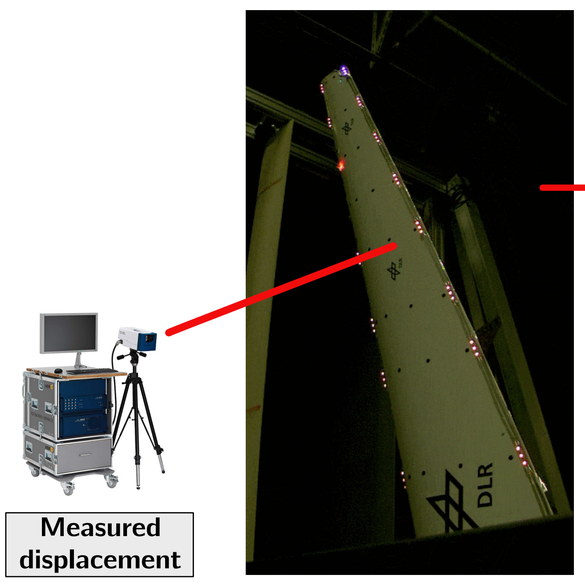


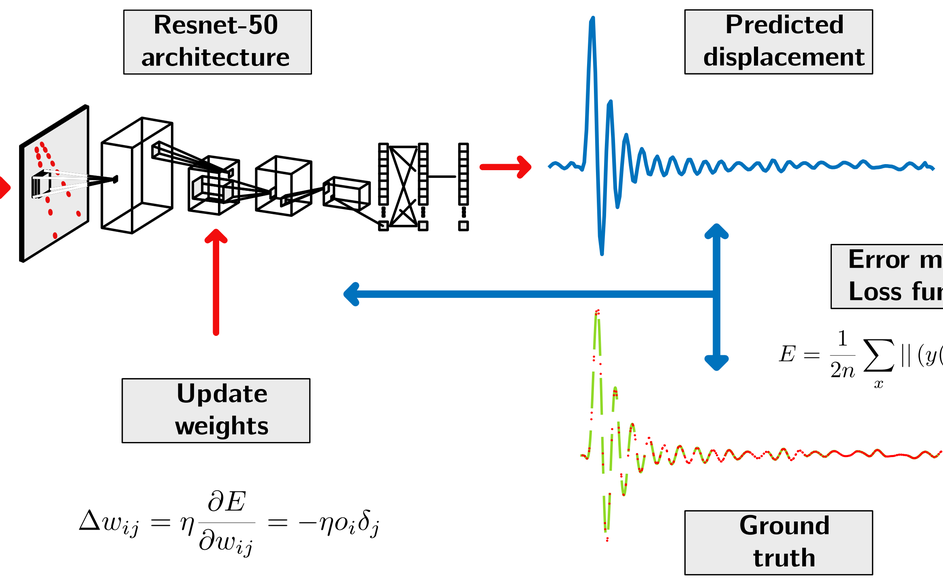


Planning Smart-X



Current work with DCNN





$$\Delta w_{ij} = \eta \frac{\partial E}{\partial w_{ij}} = -\eta o_i \delta_j$$

$$E = \frac{1}{2n} \sum_x || \, (y(t) - y'(t)) \, ||^2$$