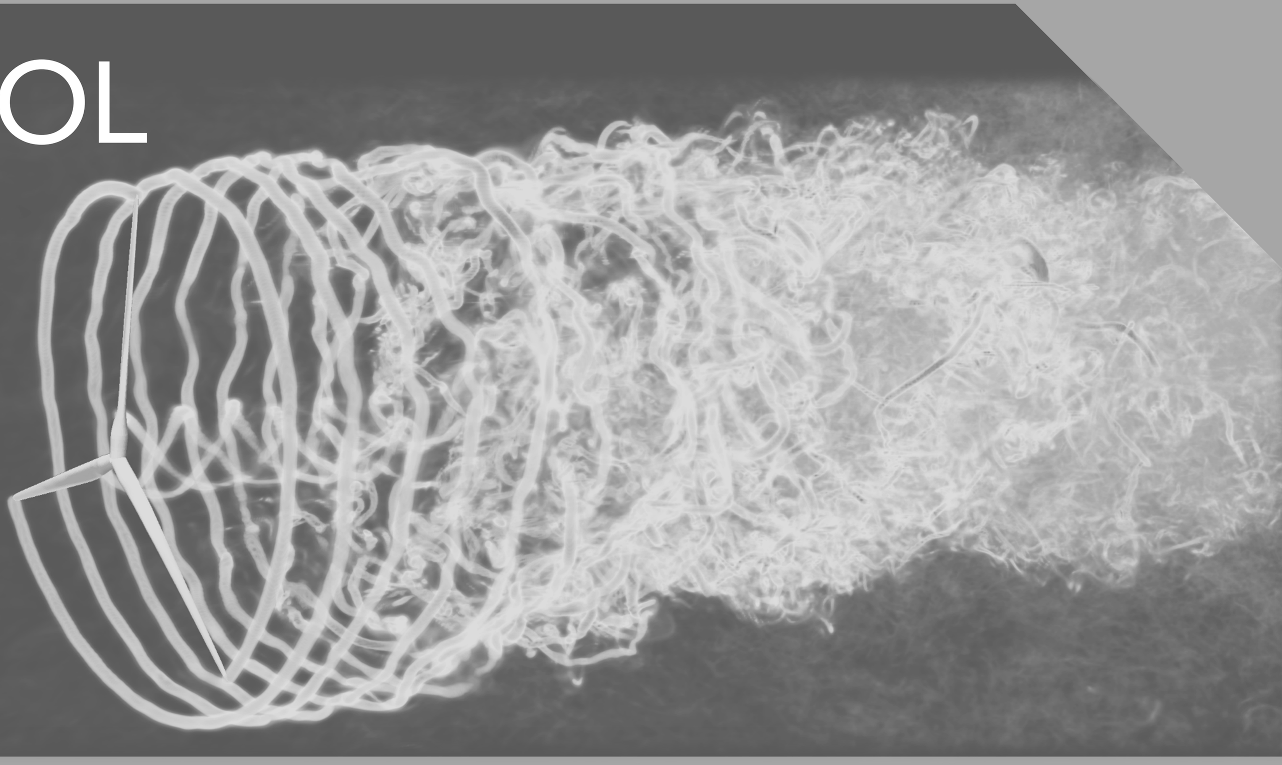
# BIOMIMETIC INDIVIDUAL PITCH CONTROL FOR LOAD ALLEVIATION

M Coquelet[1,2], L Bricteux[2], M Lejeune[1], P Chatelain[1]

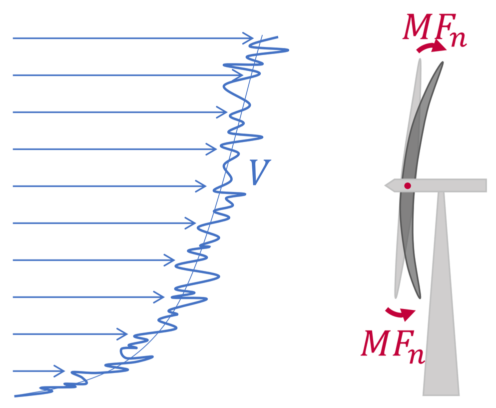
[1] Institute of Mechanics, Materials and Civil Engineering, UCLouvain
[2] Fluids-Machines Department, Faculté Polytechnique, UMONS

Marion.Coquelet@uclouvain.be

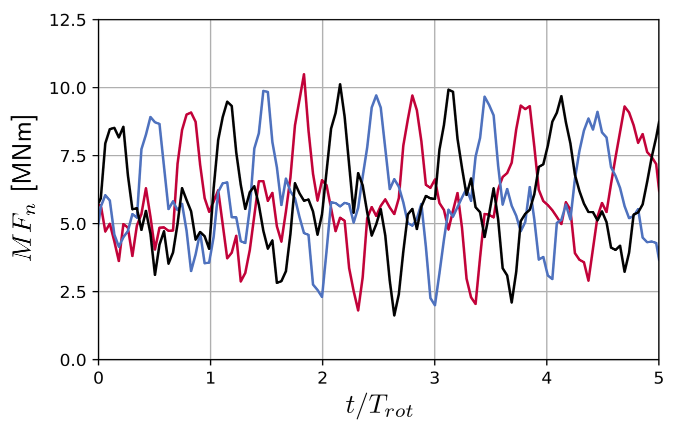


## 1 ▸ CONTEXT

→ *Presentation of a new individual pitch controller*




Variation of velocity seen by the wind tubine blades (wind shear, turbulence, yaw misalignement, wake impigement)




→ Large once-per-revolution load oscillations on blades

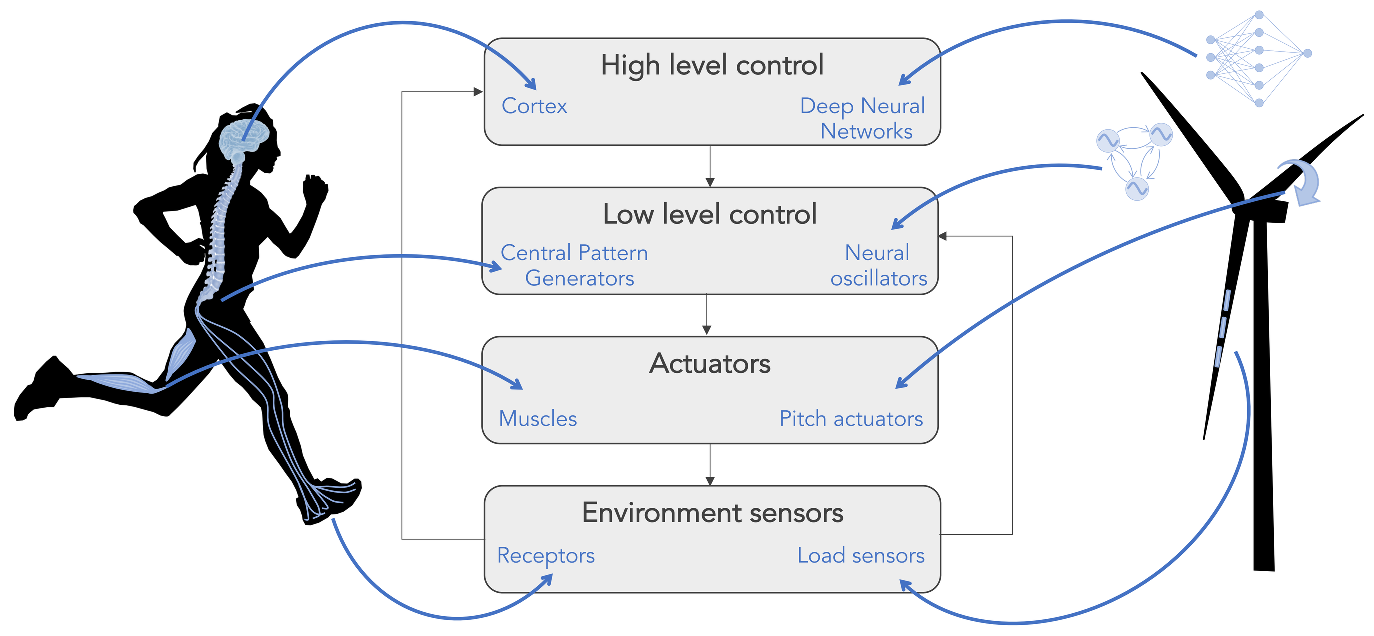
→ Fatigue load alleviation proved possible by individual pitch control (IPC) [1]

## 2 ▸ BIOMIMETISM

Human locomation:

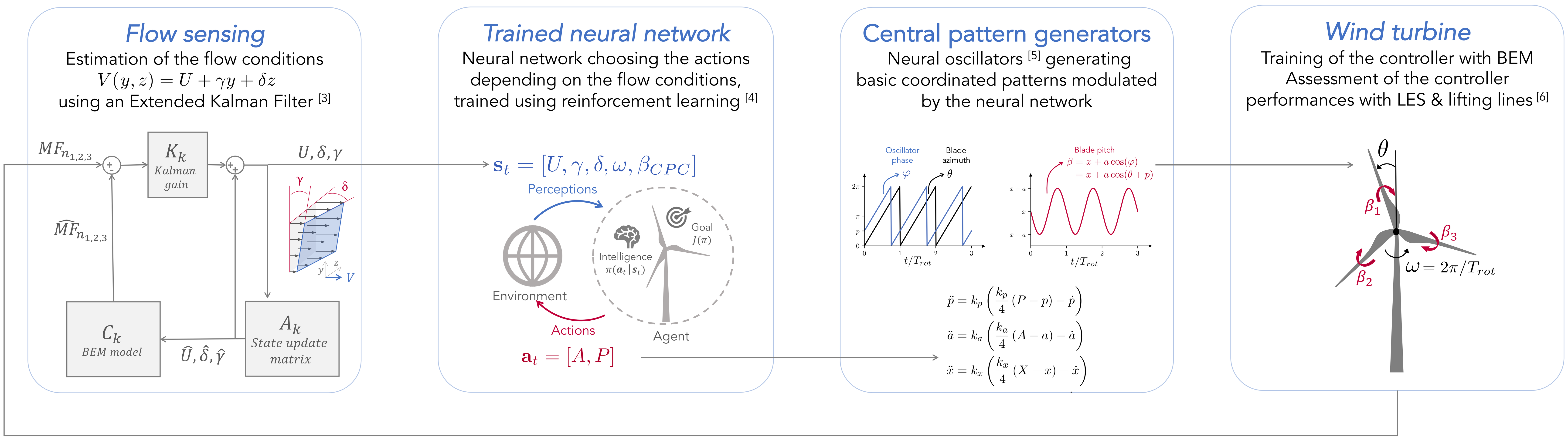
- rhythmic motion
- ability to adapt to environmental conditions

→ *Bio-inspired individual pitch controller* [2]



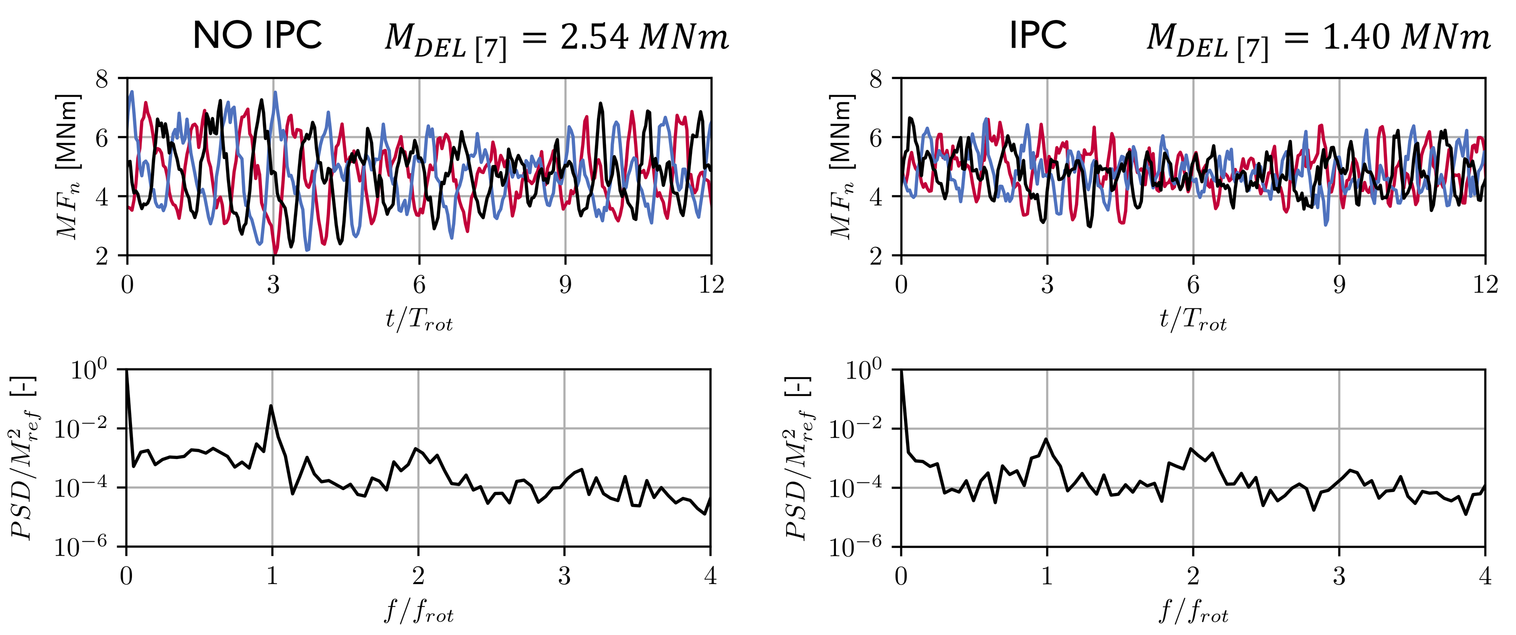

## 3 ▸ CONTROL STRUCTURE

→ *Determination of flow conditions using blade as sensors*
→ *Separation of high-level tasks and low-level ones*




## 4 ▸ RESULTS

*Assessement of the load alleviation capability of the bio-inspired IPC with LES of the NREL 5MW in a turbulent and sheared inflow*




- Limited range of actions for the controller
  - Learns how to reduce fatigue loads
    - Further load alleviation by [1] so far, but smoother commands for bio-inspired IPC

## 5 ▸ PERSPECTIVES

- Providing the neural network with local velocity information
- Adding oscillators with higher harmonics of the rotation frequency
- Made possible by **flexibility of the bio-inspired IPC**
- **Further load alleviation** expected with **smooth pitch commands**

## 6 ▸ REFERENCES & AKNOWLEDGMENTS

[1] Bossanyi *et al.*, Wind Energy 2003, *Individual Blade Pitch Control for Load Reduction*
[2] Coquelet *et al.*, Journal of Physics: Conference Series 2020 (to be published), *Biomimetic individual pitch control for load alleviation*
[3] Bottasso *et al.*, Renewable Energy, 2018, *Local wind speed estimation, with application to wake impingement detection*
[4] Haarnoja *et al.*, 2018, *Soft Actor-Critic: Off-Policy Maximum Entropy Deep Reinforcement Learning with a Stochastic Actor*
[5] Ijspeert, Neural Networks 2008, *Central pattern generators for locomotion control in animals and robots: A review*
[6] Chatelain *et al.*, Flow, turbulence and Compubstion 2013, *Large Eddy Simulation of Wind Turbine Wakes*
[7] Blasques *et al.*, Computational Methods in Marine Engineering V 2013, *Mean load effects on the fatigue life of offshore wind turbine monopile foundations*

*This project has received funding from the European Research Council under the European Union's Horizon 2020 research and innovation program (grant agreement No.725627). This research benefited from computational resources were made available on the Tier-1 supercomputer of the Fédération Wallonie-Bruxelles, infrastructure funded by the Walloon Region under the grant agreement No.1117545. Computational resources were also provided by the Consortium des Equipements de Calcul Intensif, funded by the Fonds de la Recherche Scientifique de Belgique under Grant No.2.5020.11 and by the Walloon Region.*

WAKEOPCOLL UMONS UCLouvain

European Research Council
Established by the European Commission