TECHNISCHE UNIVERSITÄT DRESDEN

DRESDEN concept

COMP-ECO Workshop

„Ice detection on composite blades using artificial neural networks under different icing conditions based on their vibration behavior“

Jan Wittig[a], Georgios Tzortzinis[a], Angelos Filippatos[a], Niels Modler[a]

[a] Institute of Lightweight Engineering and Polymer Technology, Technische Universität Dresden, Holbeinstraße 3, Dresden, 01307, Germany

Outline

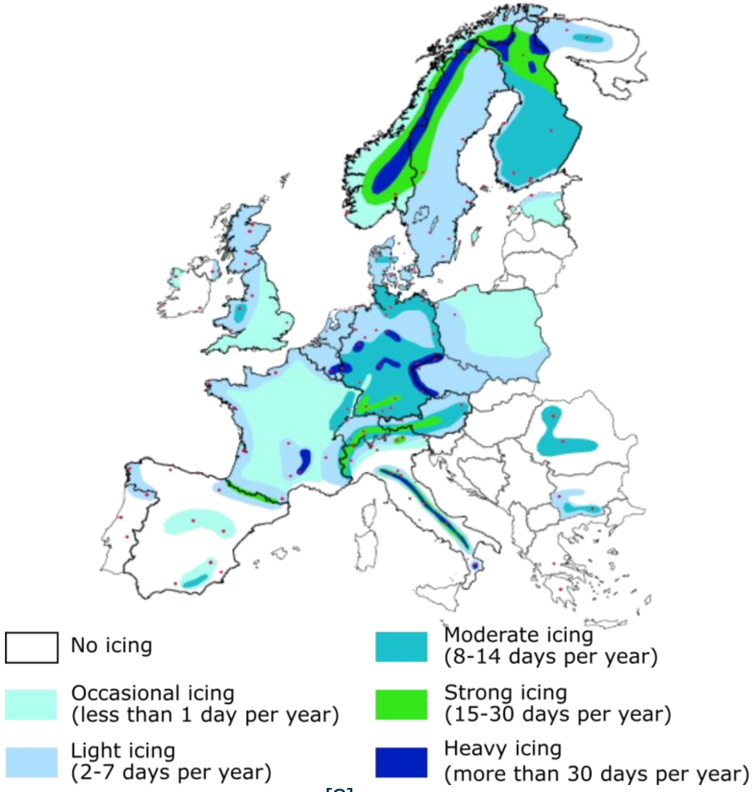
1. Motivation and state of the art
2. Methodology
3. Experimental work
4. Ice prediction using artificial neural networks (ANN)
5. Conclusion and future work

Motivation

- Wind energy substitutes electrical energy generation from fossil fuels
- Expected wind power capacity of **224 GW by 2025** [1] in cold climate regions
- The ice-induced power loss on wind turbines can reach up to **20%** [1] of the annual energy production
- Ice mass increases the wearing of wind turbine components (blades, gearbox)

➢ Demand for ice detection and prediction methods

➢ With early ice detection, deicing or countermeasures can be initiated



[2]

[3]

[1] Montoya “A Review on the Estimation of Power Loss Due to Icing in Wind Turbines”. In: *Energies* 15.3 (2022)
[2] Afzal, Faizan and Virk, Muhammad S. “Review of Icing Effects on Wind Turbine in Cold Regions”. In: E3S Web Conf. 72 (2018)
[3] B. Kahn. url: https://gizmodo.com/viral-image-claiming-to-show-a-helicopter-de-icing-texa-1846279287

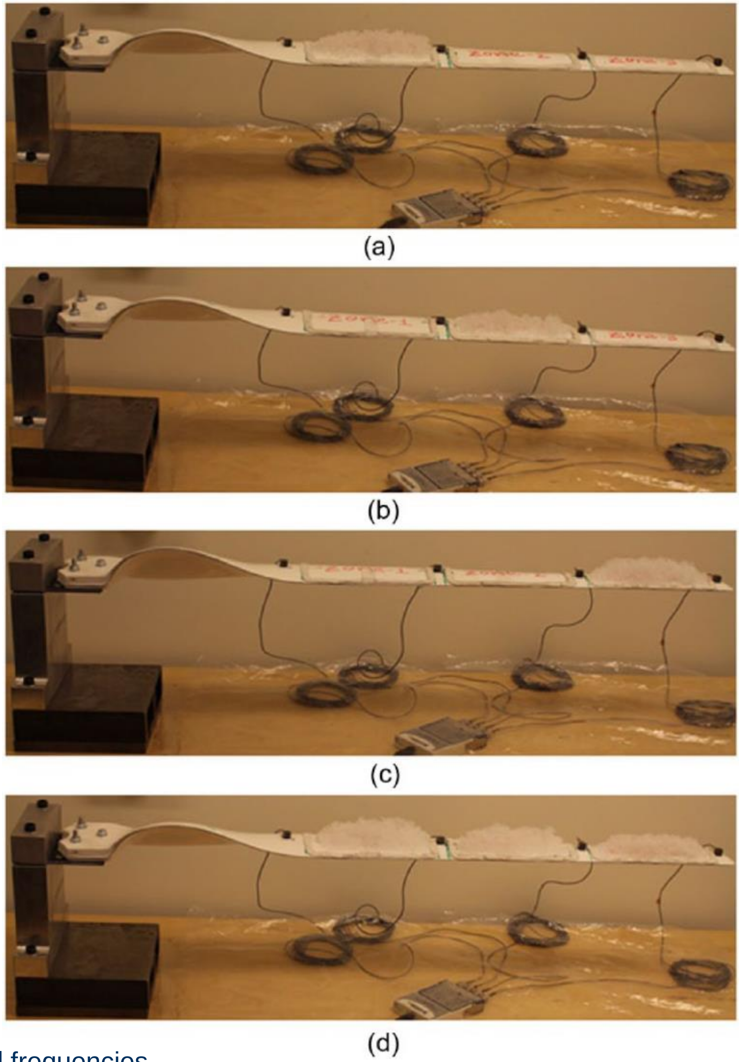
Objectives and state of the art of ice predictions

State of the art

- Frequency-based measurings have been investigated recently to predict ice mass along rotor blades
- Lack of satisfying prediction results
- Mostly **ice detection is possible, but no ice distribution prediction**
- Many investigations are conducted in static standstill conditions [4]

Research contribution of this work

- Investigation of the influence of ice on the blade’s frequency response
- Data processing procedure with artificial neural networks to predict ice thickness and ice mass on the blades



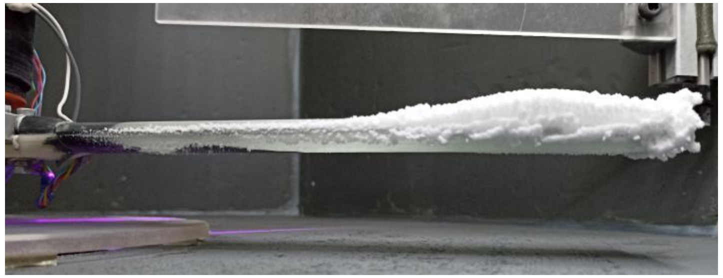
[4]

[4] Gantasala S, Luneno J-C, Aidanpää J-O. Identification of ice mass accumulated on wind turbine blades using its natural frequencies. Wind Engineering. 2018

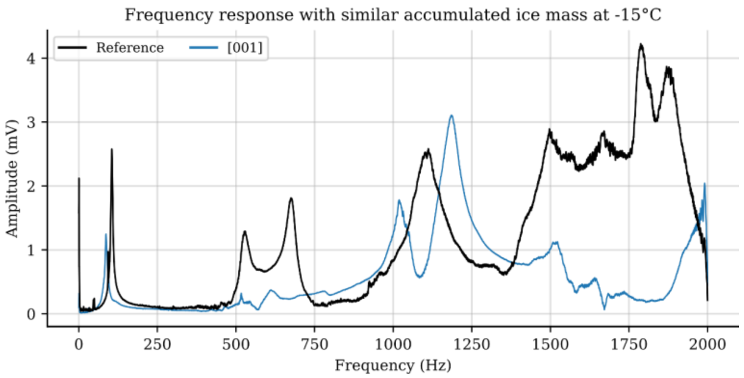
Ice prediction based on the blade‘s frequency response

Experimental work

Iced blade



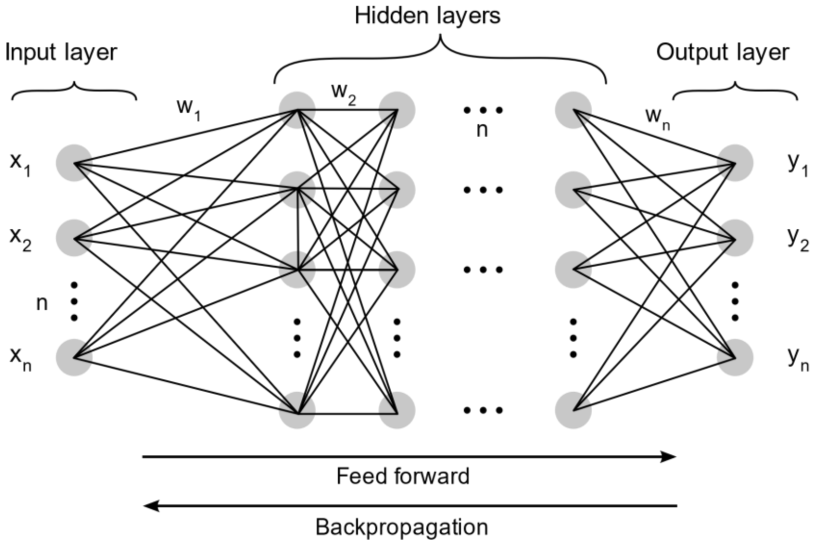
Experimental Modal Analysis (EMA)



Frequency response

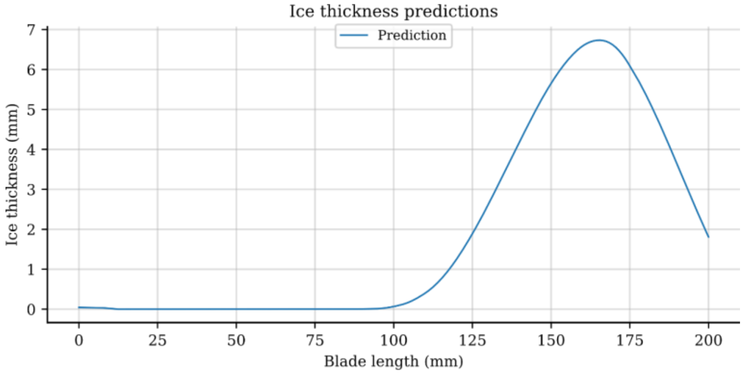
Ice prediction with artificial neural networks

Artificial neural network



Predictions:

- Ice thickness
- Ice volume and ice mass



Conclusion

Conclusion

Characterizations: influence of ice mass, ice location and ambient temperature on the frequency response

- Successfull predictions with high performance of ice volume, ice mass and ice thickness
  - Enhancement to ice prediction methods

Limitations and future work

- Artificial neural networks prediction performance is assumed to drop with similar manufactured blades, where the frequency responses are not contained inside the data set

Future work

- Development of a generalizable model that is less dependent on the blade