DYNAMIC RELATIVE BLADE PITCH MISALIGNMENT – SPREEWINDTAGE 2021

VENTUS GROUP

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Who are we?

Ventus Engineering GmbH

- Rotor Monitoring System (TripleCMAS) *patent*
- Monitoring lightning grounding system (LEDS) *patent filed*
- Inspect leading- and tailing edge in operation *patent filed*
- CTV + gyro platform for off-shore inspections *patent filed*
- Graphene containing carriers for WTG *patent*

Ventus Wind Services (AT, DK, UK)

- Nacelle based LiDAR Measurements
- Dynamic & Static Blade Pitch Measurement *patent*
- Drone Inspections *patent filed*
- Taking-Over & End-of-Warranty Inspections
- Dissolved Gas Analysis
- Wind farm BIG data analysis
- Wind Farm Optimization & Lifetime Extension
- Ventus academy and service support system
- Dynamic Blade Pitch Measurement off-shore *patent filed*

Ventus GmbH

- Extended Warranty
- Construction property damage
- Delay in start-up
- Machinery Breakdown
- Business interruption

Introduction

- The blades of a wind turbine are designed to operate at the optimal angle of attack and same pitch angle

- During the blade installation, deviations from the optimal angle of attack can be introduced, due to mechanical tolerances, human errors etc. This in addition to problems in the pitch system (bearings, actuators etc) can lead to a significant level of relative blade pitch misalignment

- Two main consequences:
  - Reduction in the Annual Energy Production (AEP)
  - Increase of the fatigue in the different components of the wind turbine

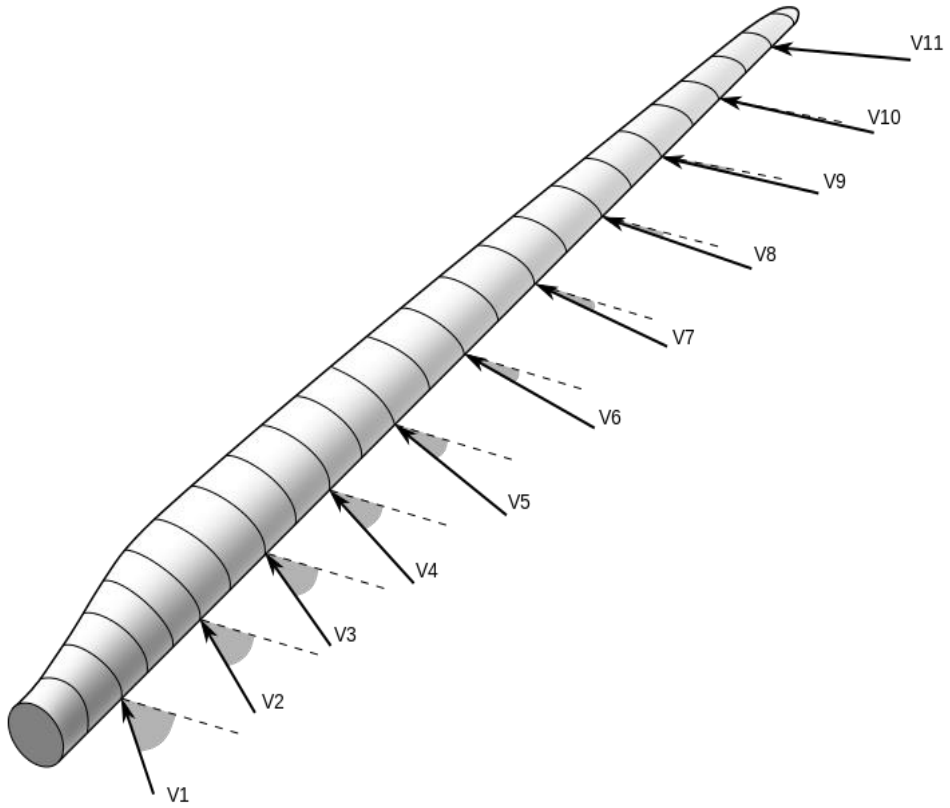


Fig.1: Angle of attack of different sections of a wind turbine blade

Problem

- Certification documents require a relative blade pitch misalignment between the blades of **±0.3°**

- The standard solution in the industry requires the interruption of the operation of the wind turbine:
  - Losses associated with the interruption of the operation
  - It is not possible to see the full magnitude and the influence of the misalignment during the dynamic operation of the wind turbine
  - Risks associated with the type of inspection (e.g. rope climbing, etc.…)

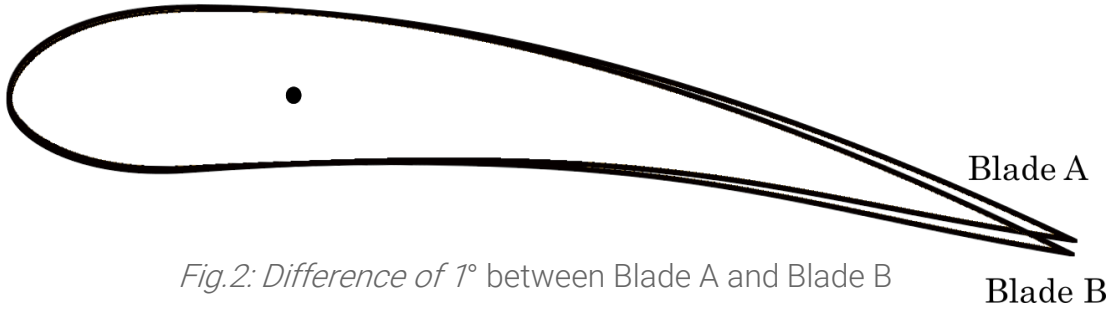
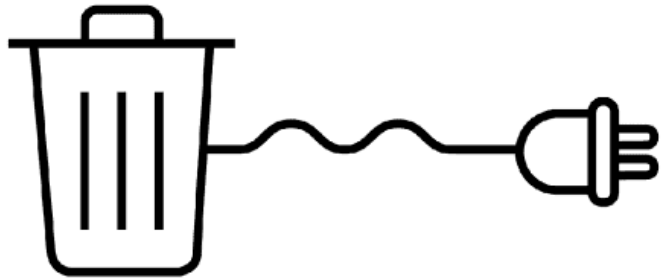


Fig.2: Difference of 1° between Blade A and Blade B



What do we propose?

- **Our field measurement setup consists of three main components:**
  - High speed camera setup configuration
  - High performance laptop with installed image acquisition & image analysis software
  - Camera carrier:
    - Tripod - Ground based setup
    - Drone - UAV setup

- **The overall measurement procedure consists of three main parts:**
  - Field measurement- Image acquisition (HW & SW)
  - Measurement quality check (Automated SW)
  - Analysis & Reporting (Automated SW)

Img.2: Drone/UAV camera setup

Img.3: Ground based setup

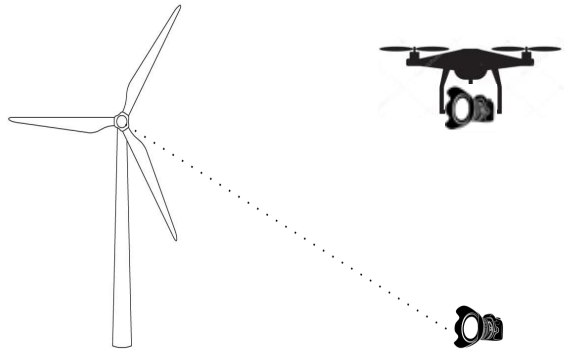


Fig.5: Positioning of the visual inspection system

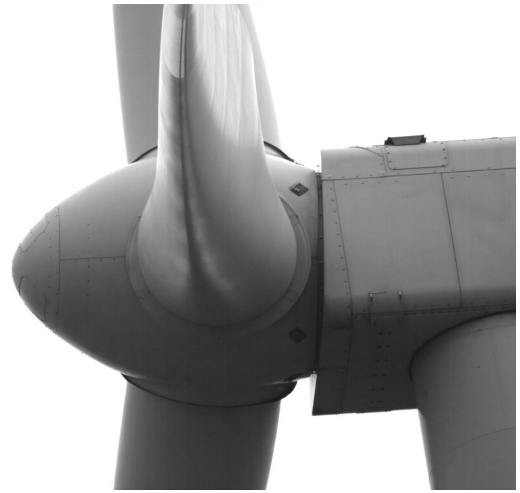


Fig.6: Example of blade passing segmentation

What do we propose?

- Positioning of the visual inpsection system in the rotor plane, with an orientation of around 120º with respect to the vertical (4 o'clock rotor position)

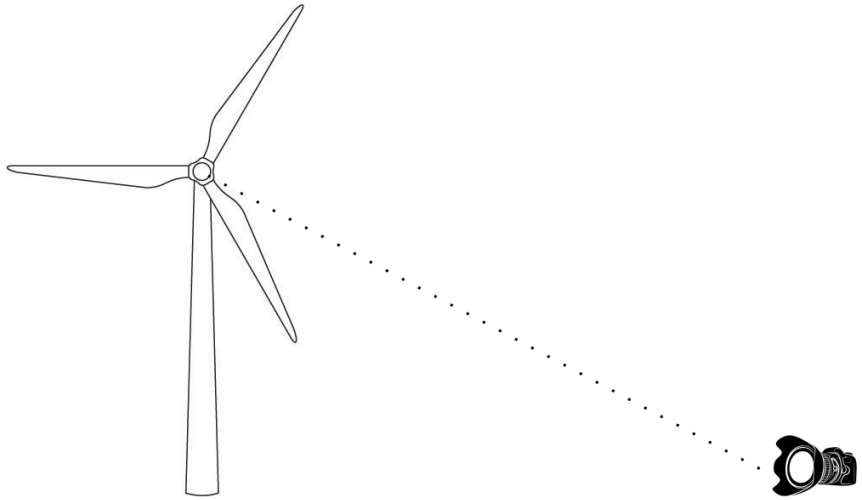


Fig.4: Positioning of the visual inspection system

- Image acquisition for every blade passing

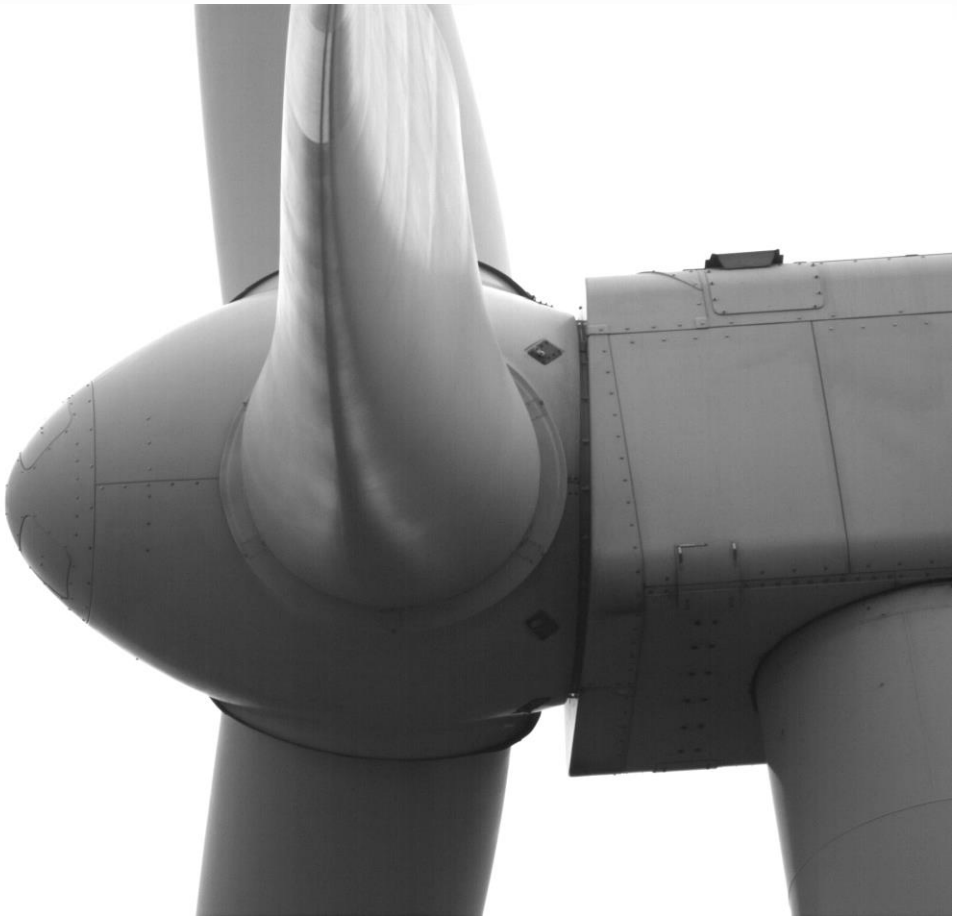


Fig.5: Set of images acquired for every blade passing

What do we propose?

- **Image analysis**
  - Identification of a reference image for every Blade passing
  - Blade labelling
  - Analysis of the Blade pitch angle for every Blade passing

- **Presentation of the results**
  - Relative Blade pitch misalignment between blades, with respect to the industry standard of **±0.3°**
  - Identification of any imperfection observed in the acquired images of the wind turbine

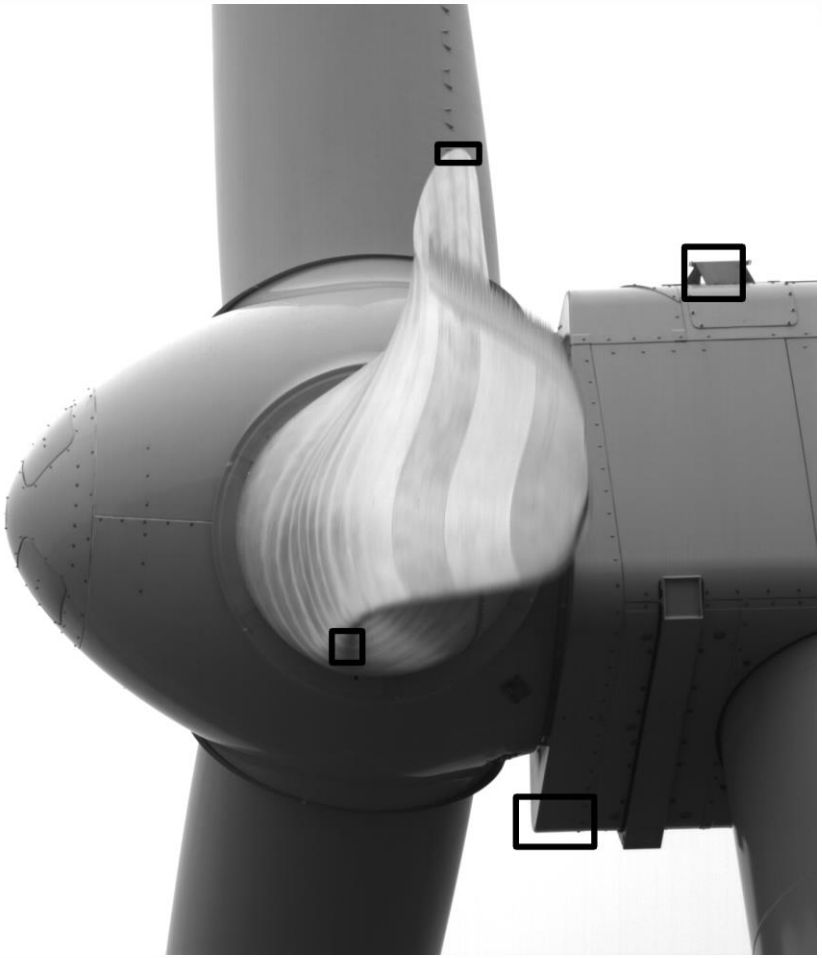
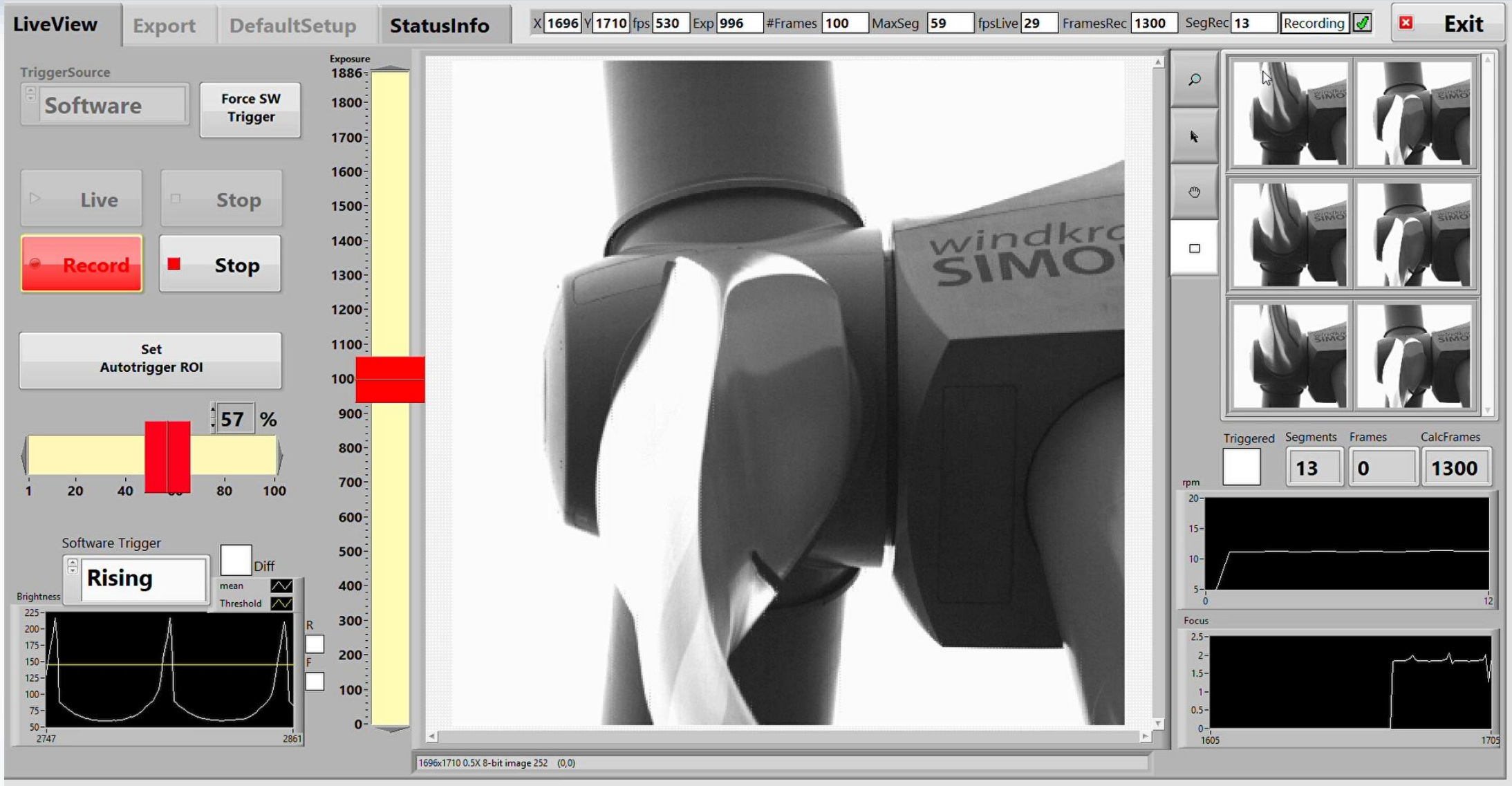


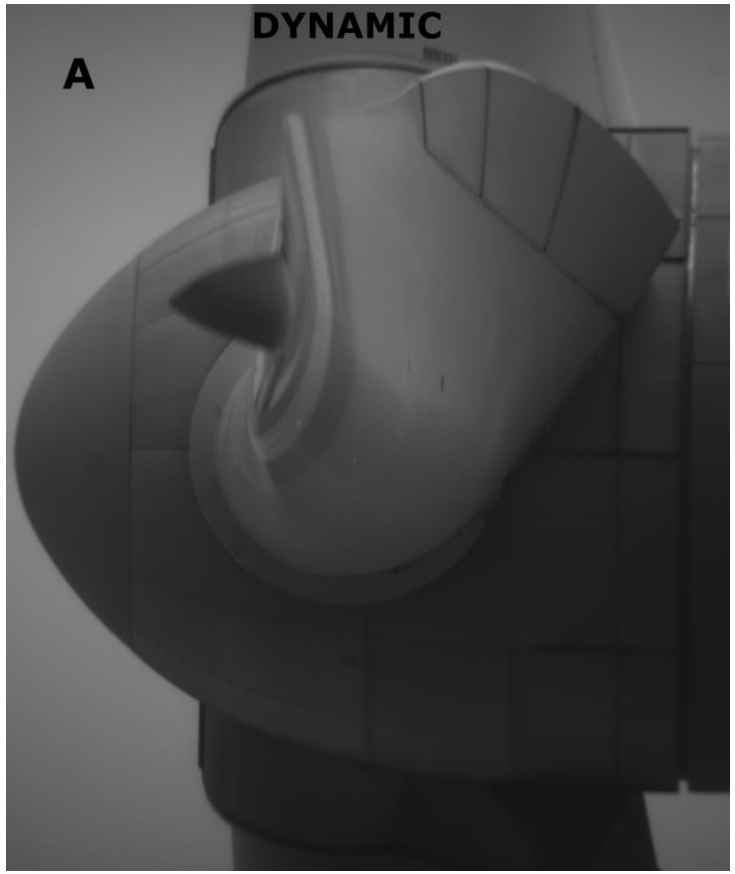
Fig.6 Example of image analysis on a reference image to obtain the blade pitch angle

Image acquisition software example

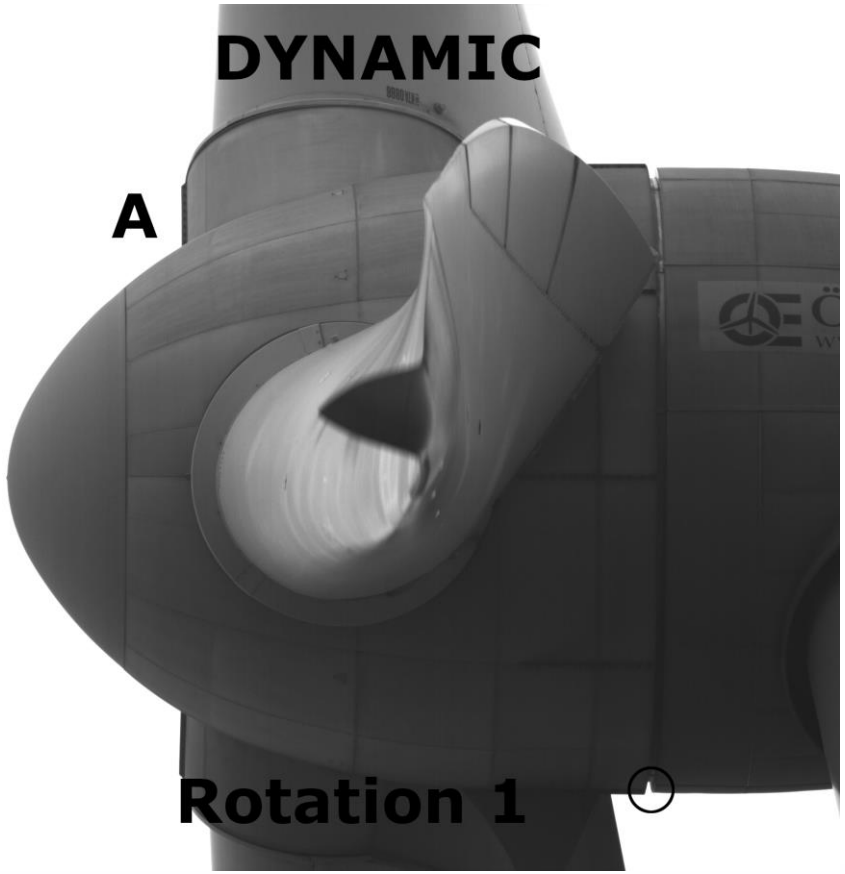


Example

Results of **Detection** (before correction)



Results of **Verification** (after correction)



Blade **A** – Blade **B**	-0.69°
Blade **A** – Blade **C**	**-2.71°**
Blade **B** – Blade **C**	-2.02°

Table 1: Results of Detection (before correction)

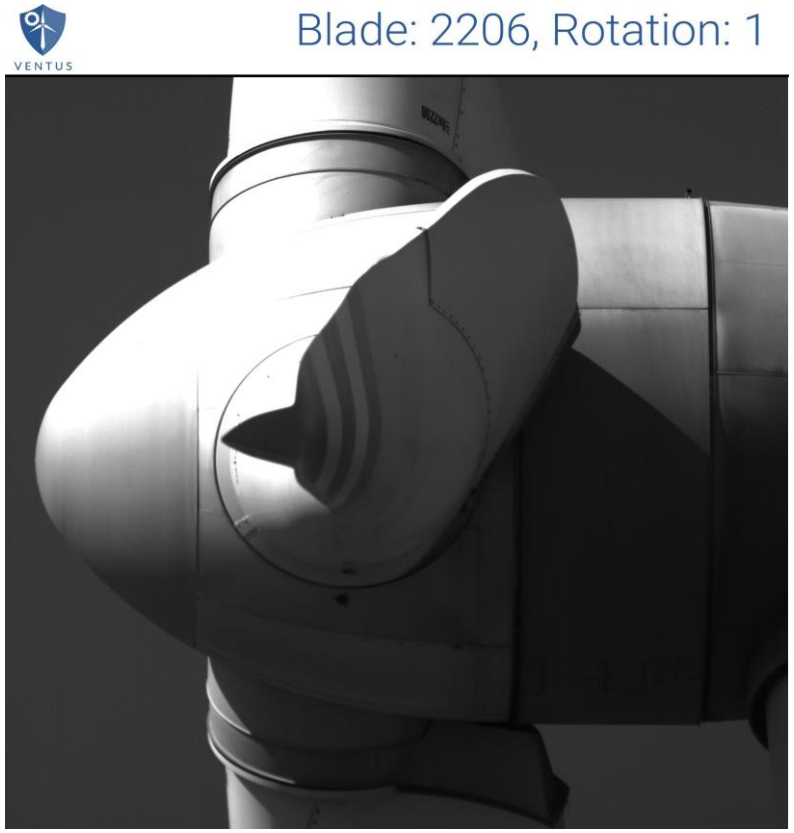
Blade **A** – Blade **B**	-0.15°
Blade **A** – Blade **C**	**-0.29°**
Blade **B** – Blade **C**	-0.14°

Table 2: Results of Verification (after correction)

Example

Results of **Detection** (before correction)

Results of **Verification** (after correction)



Blade **2206** – Blade **2200**	-0.20°
Blade **2206** – Blade **2180**	1.41°
Blade **2200** – Blade **2180**	**1.60°**

Table 1: Results of Detection (before correction)

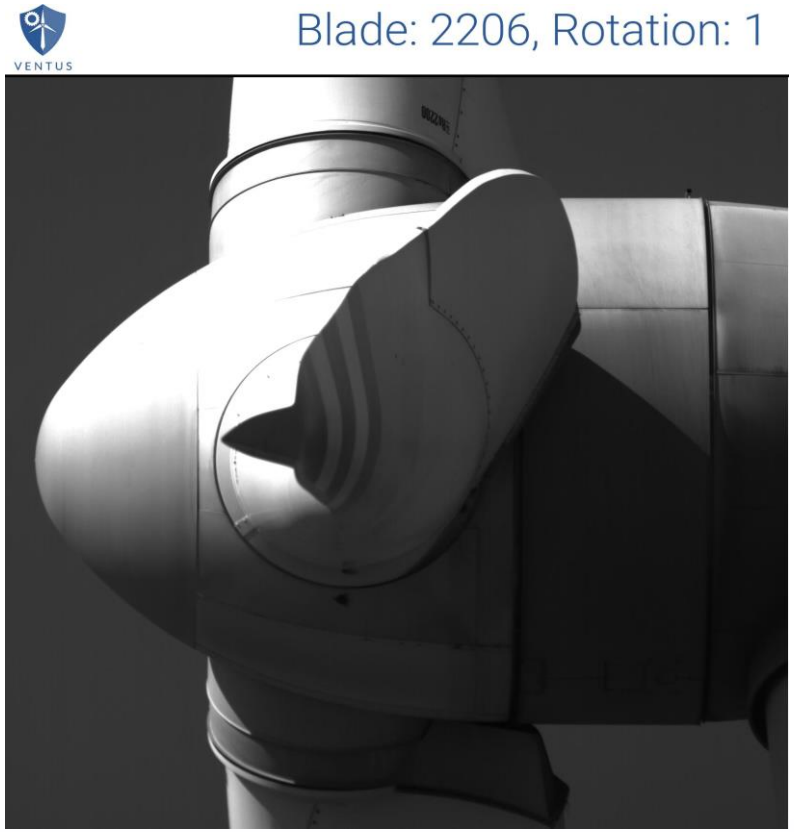
Blade **2206** – Blade **2200**	-0.15°
Blade **2206** – Blade **2180**	0.12°
Blade **2200** – Blade **2180**	**0.27°**

Table 2: Results of Verification (after correction)

Example

Results of **Detection** (before correction)

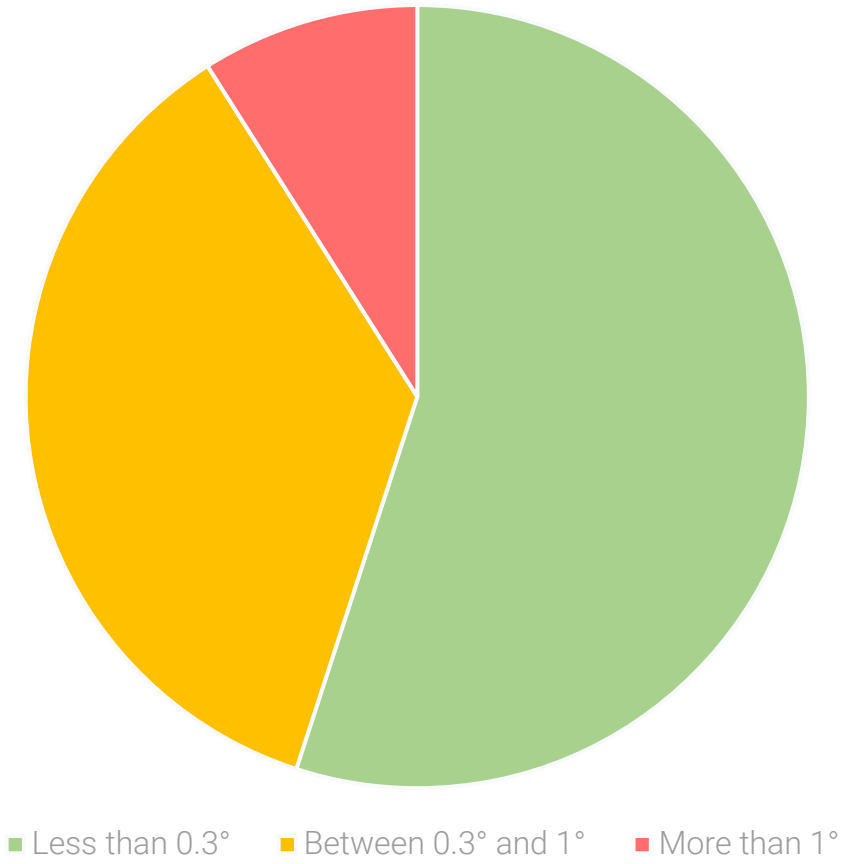
Results of **Verification** (after correction)



- In the example, the correction is properly performed:
  - The relative blade pitch misalignment is reduced below the required levels
  - Optimization of the energy output
  - Reduction of the fatigue loads, as it can be seen in the reduction of the bending differences between the blades

Conclusions

- The detection of the relative blade pitch misalignment is important to correct any errors in the blade positioning
- According to Ventus experience (more than 700 wind turbines analyzed), a **45%** of turbines has a relative blade pitch misalignment larger than **0.3º**, and **20%** of these cases the misalignment is larger than **1º**
- This suggests the need to provide this service for the highest amount of wind turbines posible, both onshore and offshore

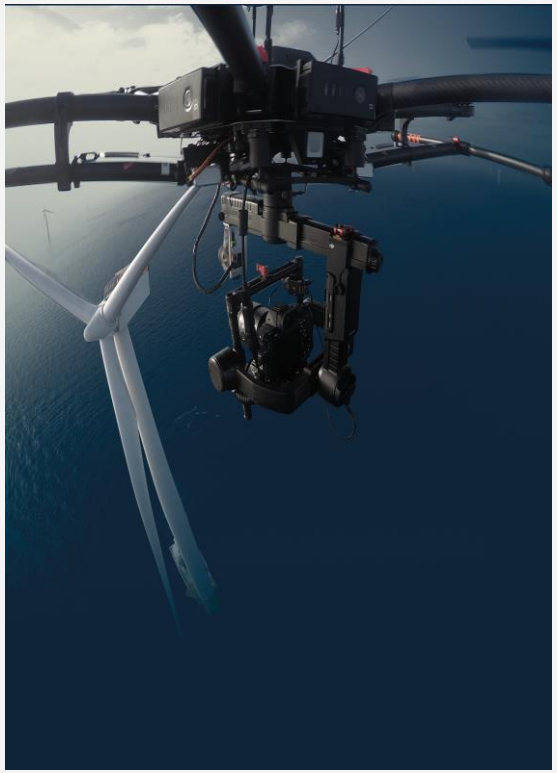


Top reasons to choose Ventus RBPM visual inspection service

- Time and cost efficient service
- All the wind turbines need this service regardless if they are new or old
- No downtime on your wind turbines while executing the service
- Very fast Return Of Investment (ROI)
- Avoiding additional loads on the wind turbines and increasing lifetime
- Increasing the output through efficiency in performance
- Observing other visual irregularities of the rotor (bending differences, cracks, loose parts, etc.)

The RBPM service is in certification process with DNV, to be finalised by the end of 2021!

THANK YOU FOR YOUR ATTENTION!



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