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CIFRE PhD Proposal

Remote inspection of Wind Turbines using 3d laser scanner on a UAV.

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Introduction

The goal of this PhD study is to enable effective inspection of rotating Horizontal Axis Wind Turbines, in order to detect blade dysfunctions that might decrease renewable energy production. This PhD will be carried out over three years in the context of a collaboration (CIFRE grant) between Alpha Wind, located in Plaisance du Touch, Haute Garonne, France, and the STORM research group (IRIT laboratory, University of Toulouse), under the scientific co-supervision of Dr Nicolas Mellado and Pr Loïc Barthe.

Research project

The main objective of this project is to explore advanced and versatile measurement and inspection tools for operating wind turbines, including challenging turbine locations such as offshore wind farms. Current wind turbine inspection methods rely on the use of a single spot laser operating at high frequency (e.g. 2kHz), or eventually on photometry technic using a digital camera. While the turbine is rotating, the laser is targeted to the turbine tower and accurate measurements are obtained from the depth variations caused by the blades passing in front of the tower. While effective for evaluating blade orientation defects and rotation speed irregularities, this system requires the laser to stand on the ground with a clear view of the turbine blades around 100m upwind of the rotor, which is not possible for offshore farms, forests or mountainous sites.

Reaching our objective thus raises two main open challenges.

The first challenge stands in the proposition of a dedicated system enabling the full 3D blades acquisition over time in all type of locations and ground/vegetal occultation. To this mean, we propose to use depth measurements obtained by a UAV. The system will have to be robust to wind and turbulences (leading to UAV motion and potential registration problems), and acquisition artefacts (missing data and noise due to lighting conditions).
The second challenge is to define an accurate 3D+time reconstruction from which both conventional and new measurements will be performed. In order to be competitive with ground acquisition, measurement will also have to reach centimeter-scale precision at high frame rates.

State of the Art

As already mentioned current turbine blade acquisitions are performed from a static ground location using single-shot [1] or 3d [2] acquisition from the ground, which are thus prone to environment occultation and restricted to steady terrains. Current solutions for offshore and difficult to access buildings (such as dams or factories) rely on embedded sensors on drones. In a recent experiment, Khadka et al. [3] evaluate the use of digital images on indoor and simple outdoor miniature turbine models equipped with markers on blades. This approach remains very experimental and the use of markers and high contrast speckle pattern on blades together with the image correlation performed on images with varying background makes it complicated to adapt to real situations. In the context of larger but static building acquisition, on-board Lidar sensors are popular and provide a direct 3D acquisition with static unstructured 3D point clouds. A first direction of research is to evaluate the quality of the acquired data in windy conditions with a dedicated reconstruction technique providing the blade geometry and topology over time.

Research organization

Acquisition and on-site testing will be operated by Alpha Wind.

The PhD student will be in charge of:

- The proposition of a dedicated acquisition system.
- The modeling, implemention and test of the algorithms to process and register the 3D data acquired over time with the drone.
- The modeling and reconstruction of the animated geometry of the turbine and blades.
- The implementation of measurement and inspection tools with comparisons to ground-based acquisition systems.

About Alpha Wind

Alpha Wind is a small French company providing services in the wind energy sector (mainly in France and Europe). We are specialized in blade pitch angle control using a patented laser system called the Romeg. The system is designed by our German partner Windcomp. The service is very efficient and provides high valuable data to our Clients in order to improve the production and lifespan of their wind turbines. Some of the advantages of the system compared to other solutions are:

- The measurement realized while the turbine is running,
- The measurement is fast (1 hour on average per turbine),

- The results are immediately available therefore an adjustment can be directly implemented,
- The measurement method is totally autonomous, we do not need any assistance from the wind turbine manufacturer,
- The measurement provides several control points (pitch angle, tower oscillations, blade clearance and blade twist).

About STORM-IRIT

STORM is a research team part of the IRIT Laboratory (UMR CNRS 5505). We conduct research on computer graphics, including geometric modeling, 3D animation and rendering. In the context of this project, we will bring our expertise on geometric modeling and on 3d point-clouds registration, reconstruction and analysis.

References

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