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Interactive comment on "Establishing a robust testing approach for displacement measurement on a rotating horizontal axis wind turbine" *by* Nadia Najafi and Allan Vesth

Nadia Najafi and Allan Vesth

nadn@dtu.dk

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Anonymous Referee #1 Received and published: 10 December 2017

General comments The study "Establishing a robust testing approach for displacement measurement on a rotating horizontal axis wind turbine" describes the experiment on a scaled model of operating wind turbine, where the blades displacements were measured using stereo photometry. The paper describes the calibration of the measurement system and the tracking procedure: the two important operations required when applying stereo photometry to operating wind turbines. Though the paper contains important findings and recommendations, which could be quite useful for those who

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Discussion paper

considers stereo photometry, paper's quality is not sufficiently high to recommend it for publication. A major revision is necessary.

RESPONSE: Thank you for reconsidering the paper and constructive comments. In the following I tried to be precise in answering and satisfying the points. * All the comments are applied to the marked document that has been attached to the supplement. ** All the page numbers, reported in the answers, are based on the marked document that has been attached to the supplement.

Specific comments

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COMMENT 1: English requires some polishing: some of the paragraphs are not quite clear because of the language. Generally, the paper is written sloppy, there are many unexplained statements; sometimes, no details provided. Also the paper does not provide any critical assessment of the suggested techniques. The text has been reworked and a discussions regarding challenges with the method's has been added. The paper claims "robust . . . measurement on a rotating . . . wind turbine", however only demonstrates the techniques on a quite small model and does not provide any considerations regarding the scalability of the measurement system.

RESPONSE: Considerations regarding the scalability of the measurement system have been added to page 15, lines 11-25.

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COMMENT 2: The reference list could be updated: during the recent years quite many measurements campaigns were reported on real size operating wind turbines, and the references to campaigns from 2002 look quite outdated.

RESPONSE: The reference list is updated: In page 2, line 2, I replaced two reference from 2002 with two new works in the same filed from 2017 and 2014 and also added a new reference from 2016 to be an example of damage detection via traditional

transducers: - Weijtjens, W., Verbelen, T., Capello, E., Devriendt, C. (2017): Vibration based structural health monitoring of the substructures of five offshore wind turbines, pp. 2294-2299, Procedia Engineering 199. - Manzato, S., Santos, F., Peeters, B., LeBlanc, B., White, J. R. (2014): Combined accelerometers-strain gauges Operational Modal Analysis and application to wind turbine data, Proceedings of the 9th International Conference on Structural Dynamics: June 30-July 2, 2014, Porto, Portugal.

- Lorenzo, E. D., Petrone, G., Manzato, S., Peeters, B., Desmet, W., Marulo, F. (2016): Damage detection in wind turbine blades by using operational modal analysis, pp. 289-301, Structural Health Monitoring. 15(3). I also provided 3 new references from 2012, 2014 and 2015 to page 2, line 4 to refere to the measurement on large structures and bridges. - Ye, X. W., Ni, Ye. Q., Wong, K. Y., Ko, J. M. (2012): Statistical analysis of stress spectra for fatigue life assessment of steel bridges with structural health monitoring data, pp. 166–176, Engineering Structures 45.

- Xia, Z., Zhang, P., Ni, Y., Zhu, H. (2014): Deformation monitoring of a super-tall structure using real-time strain data, pp. 29–38, Engineering Structures 67.

- Siriwardane, S. C. (2015): Vibration measurement-based simple technique for damage detection of truss bridges: A case study, pp. 50–58, Case Studies in Engineering Failure Analysis 4.

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COMMENT 3: Quality of the figures needs significant improvement.

RESPONSE: The quality of Figures 1 and 5 has been improved. Figures 10-13 are also vector graphics and have a very high resolution.

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Technical corrections

COMMENT 4: P.2, line 23: should be “are”, not “is”.

RESPONSE: It is corrected.

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COMMENT 5: P.2 line 32: using “well-defined” in this context is confusing.

RESPONSE: I changed the sentence to avoid the confusion: “This study is focused on establishing a well-defined clearly described and easily applicable procedure to measure displacement on the components of a rotating horizontal axis wind turbine using stereo vision technique.”

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COMMENT 6: P.3 line 14: why an Envision wind turbine is mentioned? Is it important in the context?

RESPONSE: It is mentioned to provide enough information about the case study which is a scaled down Envision wind turbine. However the Envision part is removed to avoid confusion.

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COMMENT 7: P.4 line 2. What is the “full resolution”?

RESPNOSE: It might not be the proper phrase in this sentence therefore I changed it to “full size”.

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COMMENT 8: P.4 lines 8-9. Consideration regarding the distances is very confusing. What do you mean?

RESPONSE: The sentence is rephrased to give a better understanding: This setup satisfies the rule of thumb which says the distance between the cameras should be at least 1/3 of the distance between the cameras and the test object; it can be up to 3 times of the distance as long as all the targets on the object can be seen in the stereo

image pairs.

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COMMENT 9: P. 5, line 1. How the marker shown in Fig.3 helps to avoid the mentioned difficulties? Please explain.

RESPONSE: The paragraph is revised and more explanation is added to that.

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COMMENT 10: P.6 line 17. Using term “smart device” is discussable in scientific literature. Please provide what is the functionality of the device. In the following text, usage of word “Leica” is too unceremonious. “Leica” is the name of a German company, which produces many other devices.

RESPONSE: I agree with you comment, thus I removed the term “smart device” and added more explanation to the paragraph to describe Leica Nova MS50 with more details.

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COMMENT 11: Fig. 5 seems to be rotated 90 degrees CCW. Why not to put it as it looks in reality? Same for fig.8.

RESPONSE: The orientation of the images is because of the camera positioning on the camera holder. To eliminate the confusion, I rotate the figures 4, 5 & 8 to be in the same orientation of the real world.

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COMMENT 12: P.7, line 9. Casualty: “the rotor rotates one cycle within 40 pictures” or “the camera takes 40 pictures during one rotor revolution”?

RESPONSE: I think they both have the same meaning, but the sentence that you mentioned might be more clear, therefore I replace sentence “the rotor rotates one

cycle within 40 pictures" with the sentenced that you suggested: "the camera takes 40 pictures during one rotor revolution".

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COMMENT 13: P.8 line 7. Where are "the first and second point (N1)"? It is unclear from fig.6.

RESPONSE: I added the position of the first and second points to Figure 6. In addition N1 is "the number of image sequences between the first and second position of the marker" as it is explained in page 8, line 7 and also in the caption of Figure 6.

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COMMENT 14: Do the terms "line of sight" (p.9, line 6) and "light ray" (p.10, line 11) refer to the same? If yes, avoid using the both terms, if not, please explain the difference.

RESPONSE: The comment is absolutely true, they refer to the same thing, thus I revised the text and used from line of sight in the document.

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COMMENT 15: What does Table 1 mean? How do the numbers quantify the quality of calibration?

RESPONSE: Table 1 presents the distance between the lines of sight during rotation for one of the markers and for different calibrations. The lines of sight from the marker to the cameras do not exactly intersect in the space due to the inaccuracies and the 3D position is regarded as the point with minimum distance from two lines of sight (Trucco and Verri, 1998). Therefore the distance between the lines of sight is considered as an indication of measurement inaccuracy that is mainly caused by calibration uncertainties and light reflections and also by other environmental and physical factors. The light and other environmental factors are almost the same in all the measurements in Table

1, therefore the different values of lines of sight distances are mostly due to different calibrations. For more clarification, more explanation is added to 3 paragraphs before Table 1.

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COMMENT 16: Where is point 6? The part of the discussion regarding the calibration is very unclear and confusing and require thoughtful revising.

RESPONSE: The point number is written by mistake. The correct form is “point 2 on the blade 2” (numbering of the markers is presented in Figure 8). It is also corrected in the text. I revised and also provided more explanation (to the paragraphs before Table 1) in this section.

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COMMENT 17: P.11 line 14. Is the “blade elongation” physical? I.e. the blades become longer due to the centrifugal forces? Please explain what do you mean here.

RESPONSE: This paragraph is added to page 10: “The distance between the markers will barely change during the turbine operation due to the centrifugal forces and gravity, thus the change of the distance between the markers when the turbine is rotating can be used as another indication of the measurement inaccuracy.”

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COMMENT 18: P.11 line 15. Where are the markers 1 and 2. If the marker numbers are important in the context, they should be shown in a figure.

RESPONSE: The numbering of the markers is shown in Figure 8. For more clarification, Figure 8 is referred in page 11, line 18.

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COMMENT 19: P.12 line 1. The first paragraph: why this? Please provide more

understandable explanation.

RESPONSE: I agree that more information is needed, therefore more detailed explanation about blade elongation is added to page 10 (paragraphs before Table 1).

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COMMENT 20: P.12 line 13: “by looking at pictures”... What pictures? Please provide figures’ numbers. The pictures that are taken and processed for the displacement measurement. This explanation is added to page 12 to avoid confusion.

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COMMENT 21: Fig.12 needs numbering (e.g. a,b,c). The vertical axis of fig.12c, must be U_z. Is it depth? What is the coordinate system? How the values on the graphs correlate the elongation values?

RESPONSE: Absolutely true, the numbering is added to Figure 12 and the vertical axis of fig.12c is changed to U_z which represents the uncertainty in depth. The coordinate system is shown in 5. Elongation values are introduced as an indication of the displacement measurements in this paper and are used to compare the accuracy of different calibration methods but uncertainty analysis quantifies the uncertainty of the measured displacement that is carried out with new proposed calibration method. Elongation value don’t represent an specific coordinate but the uncertainty analysis using based on the law of error propagation represents the uncertainty values in x, y (in-plane) and z (out of plane) coordinates.

Please also note the supplement to this comment:
https://www.wind-energ-sci-discuss.net/wes-2017-49/wes-2017-49-AC1-supplement.pdf

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