The Capabilities and Effectiveness of Remote Inspection of Wind Turbines

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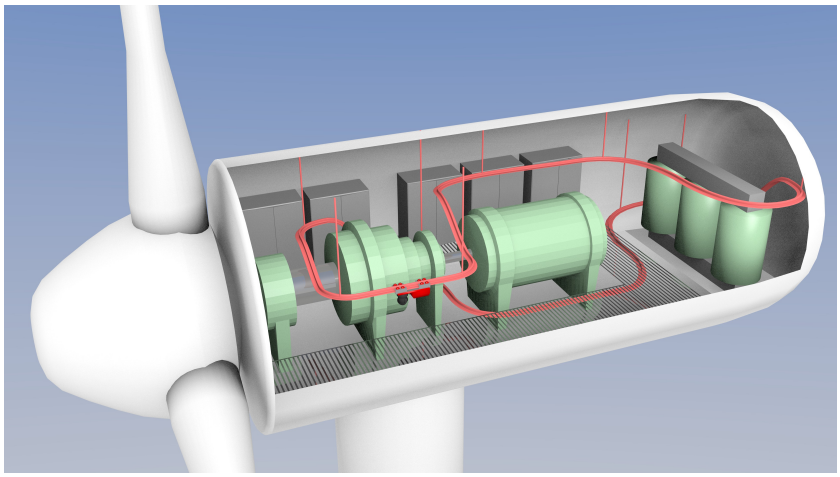
Introduction

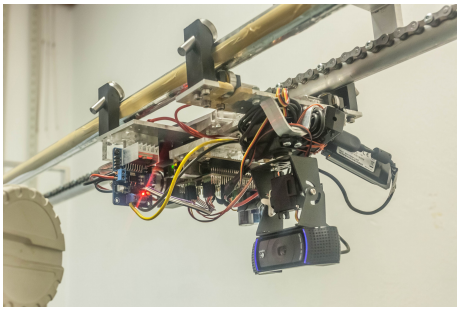
The high cost and unpredictability of access to offshore wind turbines drive the high cost of operation and maintenance. Development of more cost effective maintenance strategies will be important for making offshore wind energy a viable alternative for the future.

Remote inspection is intended to be an inexpensive alternative to the manned inspections performed today. A robot installed inside the turbine, as shown to the right, can be used to do inspections on behalf of a technician on land. Sensors on the robot can gather the same information as a human on site would with his own senses.

A usability test of remote inspection and a discussion of its capabilities for offshore wind turbines is presented here.



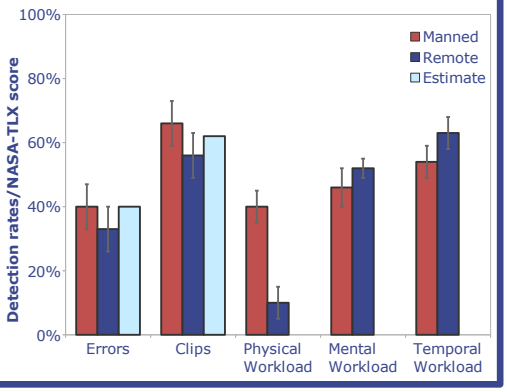
Usability Test in Laboratory



Usability testing is a method for evaluating participants ability to use a system for relevant task. A usability test with 31 participants was performed, where remote inspections were compared with manned in a laboratory setting.

- A simple remote inspection prototype was used, as shown above.
- Only visual inspection was tested.
- The video from the robot was shown to the user on a 24 inch computer screen.
- The prototype was controlled with the touch screen of a tablet computer.

The inspections consisted of searching for «error markers» (realistic error conditions) and «paper-clips». The ratio of these that were found is considered to be a measurement of the effectiveness of the inspection. In addition the participants filled in a NASA-TLX workload assessment after each inspection. The detection rates of the error markers and paper clips is shown in the graph together with some selected NASA-TLX results. The error bars represents 95% confidence interval.



Capabilities

The experiment was not intended to evaluate remote inspection in a realistic setting. This will be evaluated in future field trials. Four inspection methods have been identified as promising for such evaluation, and is presented here:

- Visual – To detect visible wear, cracks, spill and cable problems.
- Thermographic – To detect heat-spots from friction or electrical problems.
- Vibration – To detect problems with rotating machinery.
- Audible – To detect changes in the sound generated by equipment, and can to some degree get the same information as vibration measurements.

A potential problem for remote inspections is that errors that are identifiable during manned inspections for some reason is difficult or impossible to identify remotely. Examples of possible reasons for such problems are:

- Robot not able to move to location where an error is visible.
- Insufficient quality of sensor information.

Discussion

It is considered more difficult to do a task remotely than in person, which is also suggested by the results in this experiment. However, the difference between the effectiveness of the inspections methods is small enough for remote inspections to be considered a promising alternative, especially with further improvements to the system.

The improvements in the robot control since the previous experiment made controlling the robot easier. Unfortunately the time given to the participants were not long enough to properly test the interface for manual control. It was observed that the robot control method allowed the participants to browse systematically through the laboratory, which was the intention. This systematic approach should be beneficial for the inspections, and is easy to combine with inspection checklists etc.

Even if it is acceptable that remote inspections take longer, it should be a prioritization to improve the remote inspection system on this point. It was also observed some limitations with the camera, especially with the ability to differentiate between similar colors, as indicated by one error marker that was never identified during the remote inspections.

Future Plans

The next step for the project is to install a prototype in a real wind turbine for field trials. This will provide an opportunity to test the aspects that were impossible to test in the laboratory.

Currently, two field trials are under planning:

- Evaluation of a simplified prototype in co-operation with VIVA test center.
- Evaluation of a fully featured prototype in the NOWERI floating research turbine in co-operation with NOWITECH.

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