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Automatic detection of the wind turbine blade surface cracks based on image segmentation

Mr.A.R. Aravind,
Assistant Professor,
Prince Shri Venkateshwara Padmavathy Engineering College, Chennai 127
ar123aravind@gmail.com

Bharati. S[2],
Final Year Students
Prince Shri Venkateshwara Padmavathy Engineering College, Chennai 127
bharathisrinivasan41@gmail.com

Geethalakshmi.G[3]
Final Year Students
Department of Electronics & Communication Engineering,
Prince Shri Venkateshwara Padmavathy Engineering College, Chennai 127
geethalakshmi0199@gmail.com,

Abstract

Electricity production plays a serious role in our standard of living as a result of alternative energy could be a renewable resources offered in nature that's not harmful to our surroundings. A data-driven framework is projected to mechanically find turbine blade surface cracks supported pictures taken by remote-controlled aerial vehicles (UAVs). Haar-like options are applied to depict crack regions and train a cascading classifier for detective work cracks. Two sets of Haar-like options, the initial and extended Haar-like options, ar used. supported designated Haar-like options, Associate in Nursing extended cascading classifier is developed to perform the crack detection through stage classifiers designated from a collection of base models, the Logit Boost, call Tree, and Support Vector Machine. within the detection, a camera is applied to find crack regions supported developed cascading classifiers the extended feature set. The effectiveness of the projected data-driven crack detection framework is valid by each UAV-taken pictures collected from a wind farm operator.. The extended cascading classifier is compared with a cascading classifier developed by the Logit Boost solely to indicate the image-based crack detection. A process study is performed to more demonstrate the success of the projected framework in distinctive the quantity of cracks and locating them in original pictures.

Keywords: Image Processing, Matlab, MEMS sensor, UART, LCD, Buzzer.

1. Introduction

Wind generation systems have been at the center of much attention during past decade as a sustainable source of energy. wind power generation capacity has grown at a fast rate of 20-30% per year. To increase the wind power acquisition and conversion rate, the size of wind turbine blade is becoming larger and larger. However, huge blade structures will increase the opportunity for failure. The long, thin and elastic blade is the part that suffers the most complete forces, which can easily cause vibration. Frequent and violent vibrations can lead to the cracking of a blade, which adversely affects the wind power generation. Moreover, unbalanced rotation caused by a damaged blade may result in serious secondary destruction, such as the collapse of the whole wind turbine. The wind turbine blades vibrate during operation and the vibration signature pattern changes with the development of structural damage level Condition monitoring is the process of measuring parameters of machinery condition, in order to identify an important change that is indicative of a developing damage[1-6,17-18].

As a major component of Wind Turbines, failures of WT blades can lead to the significant capital loss and unscheduled downtime. Previous studies reported that each blade failure could result in a downtime of more than 7 days. Pulsating wind loads and environmental factors, such as the lightning, dust, and icy weather, actually make blades fragile parts of WTs. Monitoring WT blade conditions and identifying blade defects based on signals measured by various sensors including the vibration sensors, acoustic emission sensors, strain sensors, and ultrasonic sensors has been vigorously studied. The conventional methods of blade vibration signal monitoring involve placing strain gauges of accelerometers on the blade[7,19-22].

However, these approaches are sensitive to electro-magnetic field and lightning, which will cause incorrect reporting of blade condition[3]. In addition, the extra installations may change the blade original dynamics. The employed sensors are usually limited because of the cost issue. But if the number of sensors is not enough to cover all the expected measured positions, it will lack blade condition information. In studies of the Wind Turbine blade defect diagnosis, Acoustic emission sensors were most frequently utilized and a number of statistical methods were applied to analyze Acoustic emission signals. In turbine technologies, different turbine-generator topologies, both direct drive and geared, have been proposed and developed by manufactures for wind turbine applications. In order to detect the defects on wind turbine blades more safely, conveniently, and accurately, a defect detection method for wind turbine blades based on digital image processing[8-10]. Based on the SPM algorithm was used to identify and classify the defect types. Accounting for 18% of the total turbine cost, Wind Turbines are a major challenge for maintenance due to the large-scale, on-tower location, and composite materials. The annual Operation and Maintenance cost of a wind farm is in the range of 0.5–2.2 cents/kWh depending on turbine size and the useful life of the turbine. As wind turbine size increases, and with that the initial capital investment, there is an increasing need to monitor the health of these structures. A fundamental action for the operation is the acquisition of early indications off structural or mechanical problems. This allows to better plan for maintenance, possibly operating the machine in a de-rated condition rather than then taking the turbine off-line or, in case of an emergency, shutting the machine the machine down to avoid further damage.

2. Related works

In this paper [2,11], It proposes an urgent addition to protect human life on wind turbines, suggest an improved surge protection approach to safeguard wind turbine electronics, simplifying the lightning protection standard by eliminating inapplicable sections , and identifies a vital aspect of wind turbine design. Finally, it is clear that the high impedance connections between rotor and ground are a major shortcoming in wind turbine LPS design that must be targeted for improvement.

The standard can be simplified and strengthened by eliminating strategies that do not apply to modern wind turbines generators such as LPLs, Rolling spheres, LPZs.

In this paper [12,14], They suggests that Betz could also be supported the incomprehensible derivation and assumption that wind speed at the rotary engine is that the average of the incoming and outgoing wind speeds. This average speed is no matter the gap of the rotary engine within the increasing wind stream. Contrary to Betz, rotary engine energy can be mostly from wind fastness getting ready to the blades and shortly away at the input and output. this might offer giant discrepancies once the outgoing wind speed is way down. Separate cases of constant fastness and a conically increasing section square measure there. Betz equations might not address the fluid mechanical problems with wind decisive potency of wind turbines. An correct measuring of incoming and outgoing air temperatures could verify that abundant of the wind energy is being regenerate to heat, that doesn't take into account. the choice could also be to think about 2 or 3 cross sections of incoming and outgoing winds[15-16].

In this paper [8,13], This given combination of Archimedes Spiral turbine and Savonius turbine. They was uses the vertical axis turbine whereas the Archimedes is horizontal axis turbine. The integrated knowledge faller was answerable for the gathering of measured values like the voltage, current, rev and battery share. Wind speeds, rotary engine speeds, and generated voltages were conjointly measured. Relationships between parameters were then determined. Results showed that the Archimedes turbine has quicker rev and produces a lot of voltage with identical wind speed with Savonius turbine once operated on an individual basis. Savonius turbine, the low in its performance, did a complementary job throughout beginning rotation once the 2 styles of turbine wherever combined along united energy gather system. For the computation of Savonius turbine geometrical parameters, the researchers appointed a diameter of 49 cm or twenty in to suit the target structure Results showed that the study was ready to develop a useful dual-wind-turbines misusage the Savonius and Archimedes spiral principle.

In this papers [9], Drag-type vertical-axis wind turbines have an outsized beginning torsion and excellent self-starting performance, and are non-directional with relevancy wind. additionally, as a result of the utmost output happens at a tip speed quantitative relation of one or less, these turbines are often operated during a lower speed vary compared with lift-type wind turbines. However, disadvantage of drag-type wind turbines is that their output is lower per unit sectional space than that of the lift-type wind turbines. Therefore, the characteristics of a multi-blade drag-type vertical axis turbine with stationary vanes functioning as wind direction plates. Here the experimental results have shown that the turbine output is magnified by mistreatment stationary vanes. Additionally, the link between the wind incident angle of the surface and also the turbine output was examined mistreatment the projected technique for scheming turbine characteristics, that the angle of installation of the stationary vanes are variable.

In this paper [7], Identification and Control Wind turbine blade condition monitoring is necessary for planning blade maintenance. To increase the wind power acquisition and conversion rate, the size of wind turbine blade is becoming large and larger. However, huge blade structures will increase the opportunity for failure. The long, thin an elastic blade is the part that suffers the most complex forces, which can easily cause vibration frequency-based index INE can quantify

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blade vibration dynamics by calculating the strengths of up to fifth order harmonics relative to the strength of main frequency. By comparing the INEs between the two tested blade conditions, the crack location was successfully found on the damaged blade. Therefore, this image-based method and quantitative frequency based index could be used in wind turbine blade monitoring and damaged detection.

In this paper [18], At present, most of the most stream product within the international wind generation market apply centralized variable pitch management. The advantage of centralized pitch management is that it's a wind energy utilization constant, which might make sure the most power within the low wind speed section, the rated power within the wind speed section, improve the beginning performance and braking performance of the turbine, improve the flexibility of the turbine, Force conditions of little machines and blades[23-25]. The results of simulation experiments show that the unbalanced load of turbine units is an efficient management technique to boost the facility offer quality and extend the service lifetime of turbine units. within the doubly-fed variable-speed power generation system the appliance of the PR IPC management strategy is easy and doesn't need multiple complicated Coleman transformations and angle measurements.

3. Proposed method of detection of cracks based on imge segmentation

In this paper, Crack Detection Based On Image Segmentation**.** The three stage crack detection method in the wind turbine blade surface includes:

- A line detection method to quickly scan a WTB and locate crack regions.
- An edge detection method that produces a detailed representation of a crack.
- Crack quantification method that characterizes the severity of a crack (e.g., size, color). A series of artificial cracks we tend to create to manage the common characteristics of surface cracks in order that the factors that have an effect on the visibility of a crack.

3.1 Synthetic Crack Generation

A set of representative artificial cracks was generated with one-dimensional motion during a controlled fashion. It represents a random displacement from this location supported a random variety generated from the quality statistical distribution. The background color of the region encompassing the artificial cracks was outlined as either white or lightweight grey to be according to the paint color of the blade. The color of the artificial crack was varied to represent the severity of a a crack. The color of surface cracks step by step changes because deepen and becomes easier to spot in digital pictures.

3.2 The Detection Framework

If any damage is detected in the motor, gearbox other than the blades it gives the immediate alert to the wind farm operator using buzzer. The proposed technique, using MEMS sensors, used to detect the effective damage prediction in the blades. The proposed damage detection method represents global monitoring approach where, as opposed to local techniques. The camera is used to detect the images of the blades. If any fault is detected then it will show the output as shown in

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the result. These values are shown in the LCD display. If the fault condition is identified immediate precaution will be taken and the whole blade is under survilience so no damage is missed.

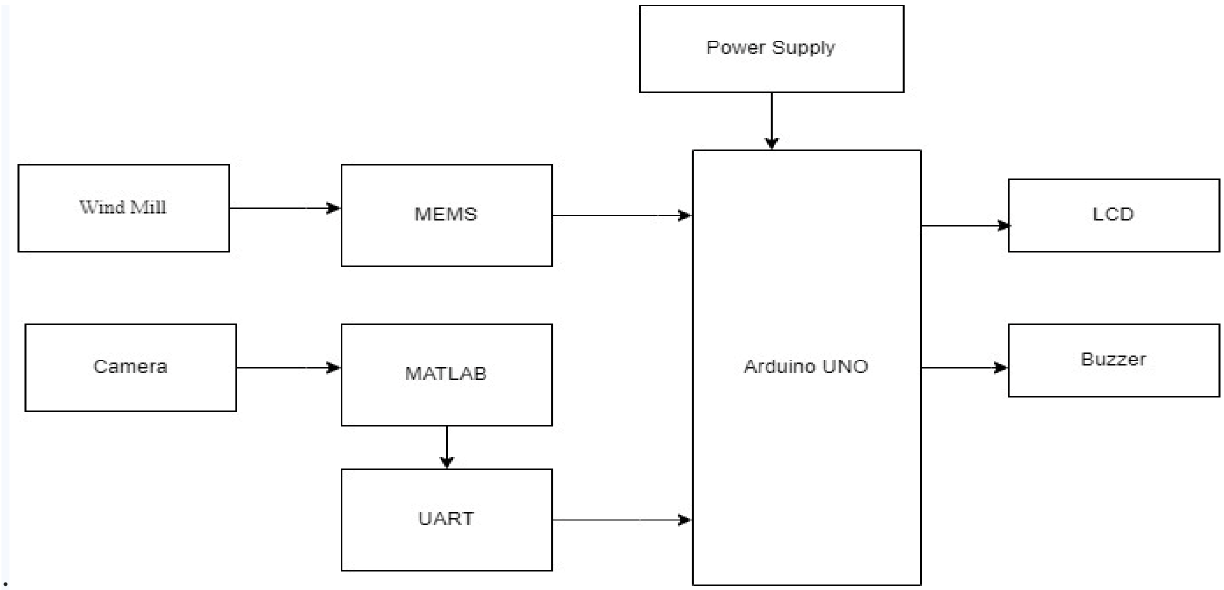

Figure 3.1 Detection of wind turbine blade cracks based

Image segmentation

4. RESULTS AND DISCUSSION

4.1 LCD RESULTS OF WIND TURBINE BLADE DETECTION

Here the camera is used to detect the cracks in the wind turbine blade surface. Two types wind turbine blades are used to capturing the image. It captures the wind turbine blade, if any damaged is detected or there is no damage in the wind turbine blade surface also noted and the output will be given to the Lcd.

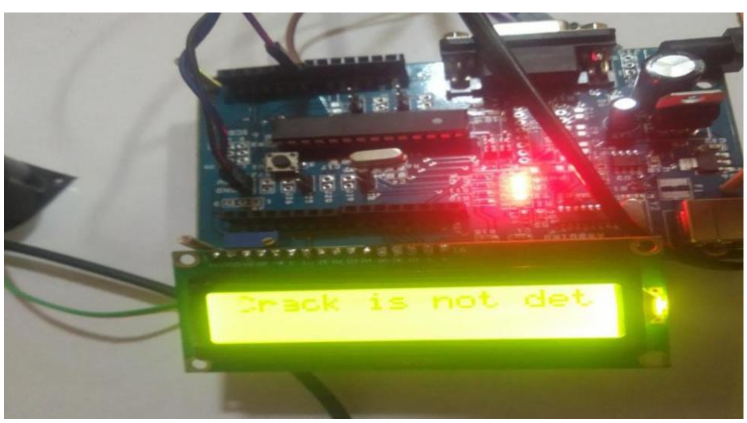

Figure 4.1 Final Detection of Wind Turbine Blade surface in LCD.

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If any fault that occur in the blade it will give the Immediate result as shown in the figure 6.1.The whole blade is under monitoring so that no defect is missed and damaged development us detected at the starting itself before it becomes critical.

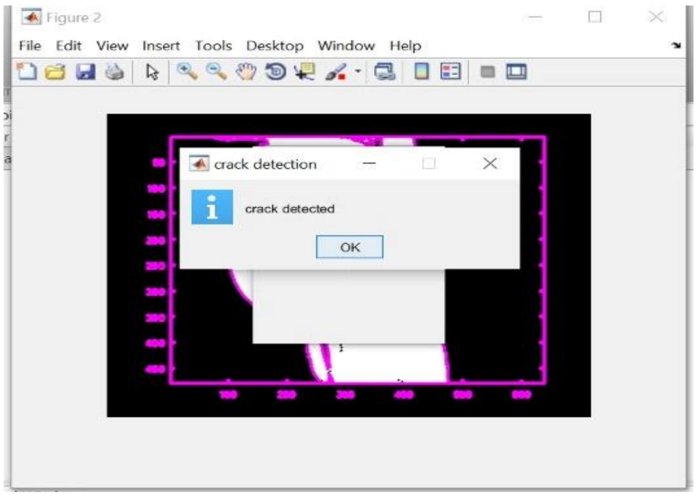

Figure 4.2 Detection of Crack Image

The figure 4.2 shows that the crack is detected, two different types of wind turbine blade are damaged and undamaged blades. We were taken the image of undamaged wind turbine blade using camera and If any fault or crack occur on the blade it will show the output as crack is detected. The fault may be heavy wind speed,accumulation of dust.

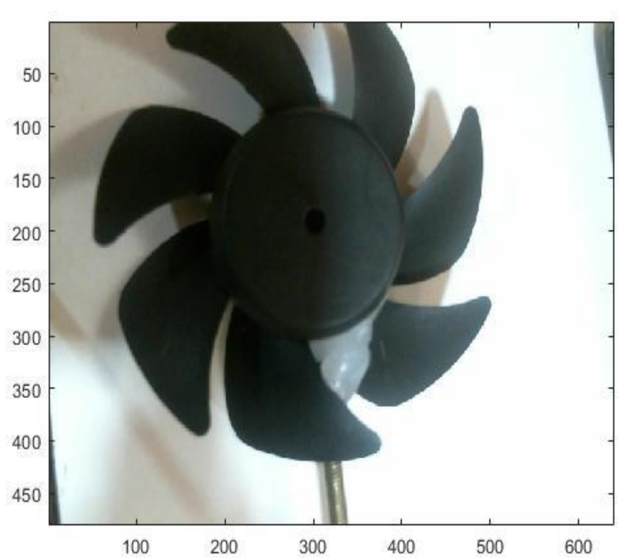

Figure 4.3 Undamaged Blade Model

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The figure 4.3 shows that the image of wind turbine model without any fault that to be used for whether the cracks occurence of the blade surface. The length and breadth of the wind turbine blade should be taken for the accurate detection of the fault condition.

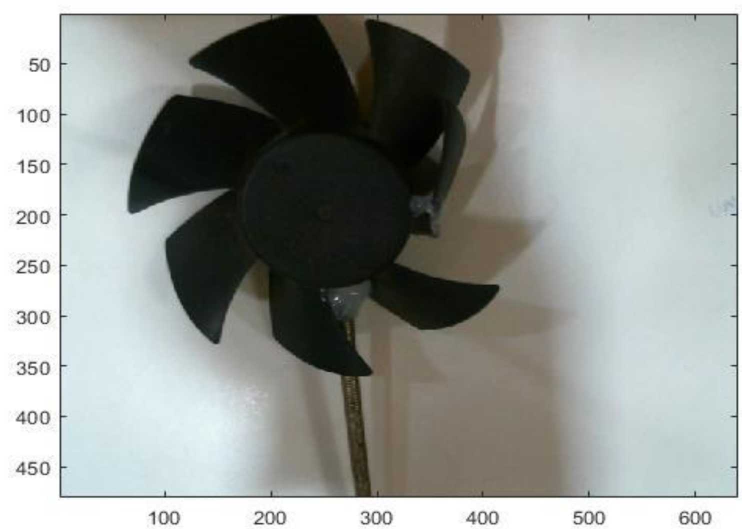

Figure 4.4 Damaged Blade

This is the reference model of our damaged wind turbine blade surface image.The camera captures the image and find out the difference between the fault and non-fault condition of the blades. If the difference is find out that is damged condition is detected it will shows the damage detection information to the lcd.

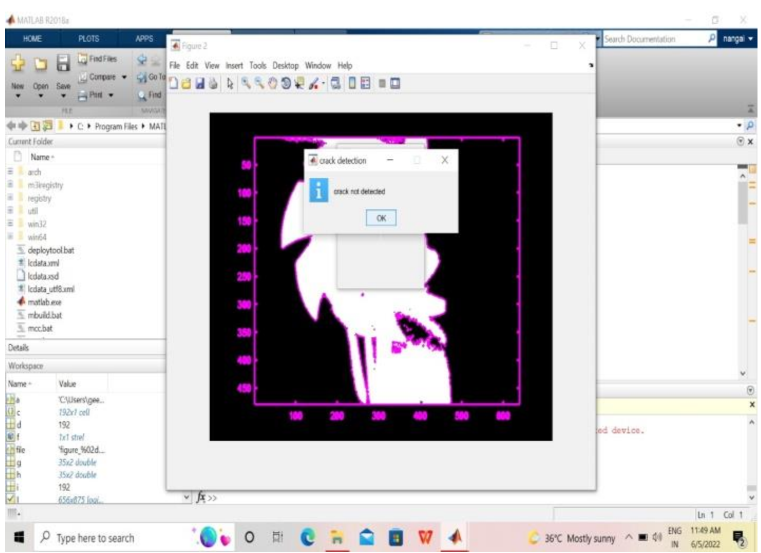

Figure 4.5 Crack Not Detection Image

This figure 4.5 shows that the crack is not detected because the area and length of the undamaged blade will be taken from dataset which was the image to be already taken by using

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camera. The length and breadth (area) of the proposed wind turbine blade surface model is taken for the purpose of fault detection. so that the difference between damaged and undamaged will be identified easily. Haar-like features are used to identify images containing blade cracks. The original and extended images are consider for the detection purpose.

4. Conclusion

A data-driven framework for mechanically detection of cracks on the wind turbine blade surface and representational process their locations supported UAV-taken pictures was developed. The frame work enclosed 2 phases, its development and preparation. The primary part developed a cascading classifier supported Haar- like features to take the images containing blade cracks. Initially taken images and the output of the images were compared with any development of damage and find regions of wind turbine blades containing cracks was conferred. With the comparative analysis of 2 Haar like feature set the classifier developed supported the exended Haar-like feature set offered the higher performance than that provided by the classifier developed supported the initial Haar-like features about as additional appropriate in developing the cascading classifier to distinctive blade cracks. To any prove the effectiveness of the data-driven framework, a UAV–taken images to make a validation dataset. A promising result was obtained through the proposed framework. Meanwhile, the detection technique was completed rapidly and this advantage allowed the potential application of the proposed framework in the wind turbine cracks.

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