Automatic Error Correction in Optimized Technology for Blade De & Re-Erection

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Abstract: ***This paper describes the automatic error correction in the field of blade lowering and raising in wind turbine where we already optimized the process of blade replacement using optimized technology [1] by eliminating the usage of heavy-duty cranes. By means of utilizing Ultrasonic, LiDAR, hall effect and loadcell sensor, we eliminate the chances for error in the operation of multiple winches simultaneously. Load shared by each winch can be identified using loadcell sensor and provide the feedback to the controller to correct the errors in the winch operation. Hall effect sensor is used to ensure that the winches are operating at proper pulses. The ultrasonic and LiDAR sensor are used to monitor the displacement of the blade while lowering and raising to protect the blade from the impact.***

Keywords: Ultrasonic, LiDAR, hall effect, loadcell sensor, Arduino

1. Background

While lowering or raising the blade using optimized technology which patented byS.AnthonyrajPremkumar for Windcare India Pvt Ltd [2], where the winches need to be operated in similar velocity irrespective of the position of the blade. Thus, a high skilled labour and complex handlinginvolves in the operation willbe eliminated which leads to less time consumption. To overcome such difficulty, the process needs to be automated and during the blade lowering & raising process, a semi-automated process is required to monitor the altitude of the blade with respect to the ground and hub as well as the distance between the blade and the tower.

2. Proposed Methodology

We proposed an approach in the optimized technology for using sensors like load cell, LiDAR, Ultrasonic, hall effect where communicate using Wi-Fi module and control using three Arduinos. With a manual initiate from work force, the process will be automated with set of conditions with proper feedback indication during the operation process and then return back to manual mode when the conditions are terminated. The loadcell sensors are used to mount on the bottom of the tower through the pulley and thus yields the load shared by both two winches. The ultrasonic sensor and LiDAR are used to mount on the tip of the blade before it used to erect from the top of the tower while the ultrasonic sensor is used to measure the altitude of the blade tip with respect to the ground and the LiDARsensor is used to measure the horizontal clearance between the blade edge and the tower. By monitoring the horizontal clearance between the blade edge and the tower, the blade can be safely lowering from its height without getting any impact. Another ultrasonic sensor is set to mount on the root side of the blade from which the height between the hub and the blade root can be measured while lowering or raising the blade using optimized technology. Eight set of magnetic pulse points are used to mount on the drum of the winches from which the winch can be operated at eight interval of pulses which further used to regulate the blade displacement. This proposed methodology's sensor positions are detailed in the below sketch figure 1.

3. Algorithm

Step 1: Start the process.
Step 2: Check whether the loadcell L1 & L2 are equal.
Step 3: If step 2 statement false, provide warning light indication LED1 and proceed to check whether L1 or L2 is greater.
Step 4: Then, energize the winch W1 if L1 is less than L2 else energize the winch W2 with maximum of six pulse trials. If exceed six pulse trials, provide warning light indication LED4 to adjust the assembly and exit the process.
Step 5: If step 2 statement true, then check the distance TBD between blade tip and tower as not less than or equal to 2 meters.
Step 6: If step 5 is true operate the winches W1 & W2 at constant feed rate, else stop the process with warning light indication LED2.
Step 7: If step 6 is true, then check whether the winch is operating in forward or reverse.

Step 8: If step 7results forward, then check the distance D between the blade tip and the ground should not less than or equal to 1.5 meters.

Step 9: If step 8 statement is true, proceed to step 5 until the distance D is equal to 1.5 meters and stop the process with warning light indication LED3 once step 8 is false.

Step 10: If step 7results reverse, then check the distance d between the blade root flange& the hub pitch bearing and it should not be less than or equal to 1 meter.

Step 11: If step 10 statement is true, then proceed to step 5 until the distance d is equal to 1 meter and stop the process with warning light indication LED3 once step 9 is true.

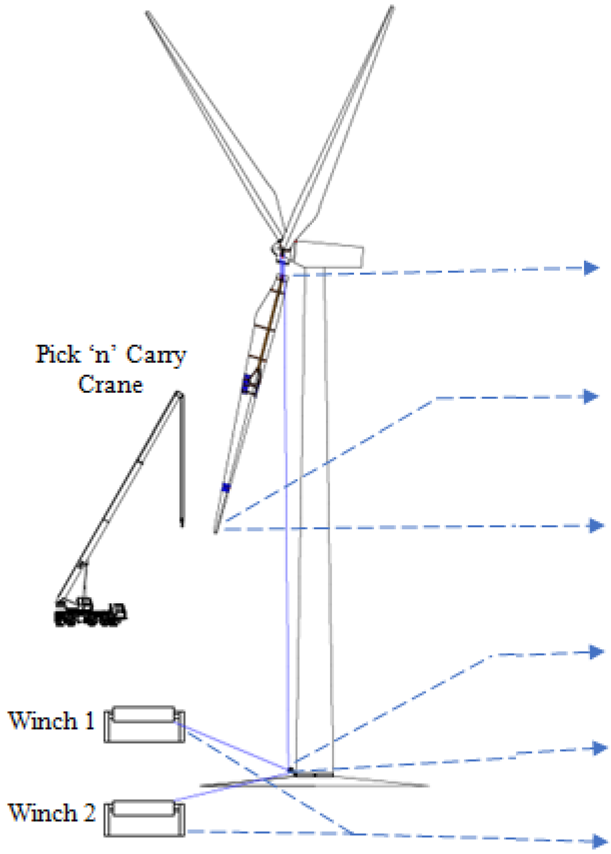

Figure 1: Proposed concept diagram

4. Block diagram

The Proposed methodology block diagram is shown in figure 2, and their blocks are explained in detail.

4.1 Loadcell

A load cell may be a transducer that's wont to create an electrical signal whose magnitude is directly proportional to the force being measured. The various load cell types include hydraulic, strain gauge and pneumatic. Use of load cell is proving load cell at bottom of crane outrigger to observe reaction changes. that means at one point where the reaction is zero at outrigger that indicates tipping of crane. The benefits of the load cell are it shows actual reaction changes at the outrigger with respect to change in load or change in angle [3].

The load cell sensors are connected in between the bottom pulley and the tower bottom jig to measure the load shared by the bottom pulley while functioning the corresponding winches. The maximum specification of a 10-ton load can be measured with a resolution of 5 Kgs. These loadcell readings will be shared with the Arduino to access the balancing of the blade between two winches while being lowering or raising. For additional safety considerations, the round slings are used to attach in between the tower bottom jig and the pulley where the load cell is used to connect. Pin diagram for the loadcell is detailed below Figure 3.

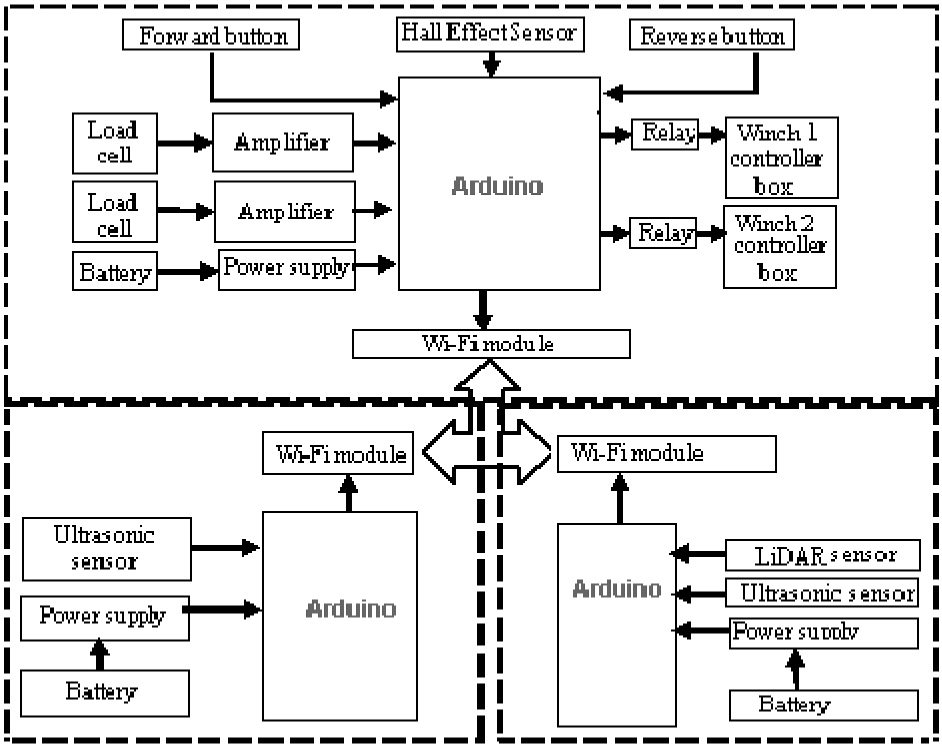

Figure 2: Block diagram

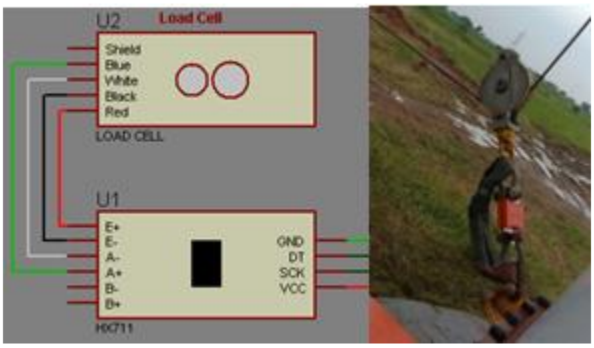

Figure 3: Load cell pin detail with implementation image

4.2 Hall Effect sensor

Hall Effect sensors are widely utilized in industrial applications for a series of low power applications, including current-sensing, position detection, and contactless switching. Such magnetic sensors, integrated into regular CMOS technology, prove to be cost-effective and offer high performance [4].

The Hall Effect is an ideal sensing technology. The Hall element is constructed from a thin sheet of conductive material. The output connections for these sensors are made perpendicular to the direction of current flow and under the influence of a magnetic field, it responds with an output voltage proportional to the magnetic field strength. The voltage output is typically very small within the range of microvolts and requires additional electronics to realize useful output levels. When the Hall element is combined with the associated electronics, it forms a Hall Effect sensor. The heart of every Hall Effect device is the integrated circuit chip that contains the Hall element and the signal conditioning circuitry [5].

The eight sets of magnetic pulses are made to assemble on the drum of the winch through which we can operate the winch with short pulses that yields the winches to operate the wire rope at a slower feed rate. This will be more useful when the blade is raised or lowered near the critical locations near the tower or the ground. Based on the blade weight, the number of falls between the pulley in the adjacent blade and the pulley in the receptacle may vary. Considering the receptacle design, it can be further tightening and aligned to a maximum of one foot from the initial pre-tight assembly. Hence, the trials to tight the receptacle can be initiated on winch operation through the Hall effect sensor in operation with seconds. The number of trials is directly proportional to the number of falls between the above-said pulleys, the maximum allowable tight limit of the receptacle and the winch operation speed. Pin diagram for the hall effect sensor is detailed below figure 4

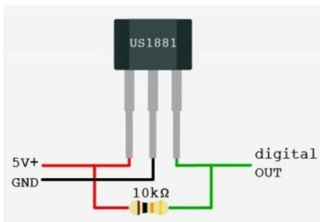

Figure 4: Hall effect sensor

4.3 Ultrasonic sensor

A sensor is an device that maps an environmental attribute to a quantitative measurement. Each sensor is based on the transduction principle which is the conversion of energy from one form to another form. There are two important termsrelated to any sensor [6]

- Target Angle –This term refers to the tilt response 'limitations of a given sensor. Since the ultrasonic waves reflect off the target object, target angles indicate acceptable amounts of tilt for a given sensor.

- Beam Spread – This term refers to the utmost angular spread of the ultrasonic waves as they leave the transducer.

These sensors as shown in Figure 5, are used to assemble on both the tip and the root flange of the blade. The sensors are connected with the Arduino and then the data will be shared through the Wi-Fi module. Thus, the blades tip and root flange position will be accessed with respect to the winch's operation. The ultrasonic sensor's pin diagrams are detailed below.

Figure 5: Ultrasonic sensor with pin details

4.4 LiDAR sensor

(LiDAR) sensors are the most essential for autonomous vehicles because they measure the distance between an object where we placed in the blade and an object and recognize the object [7,8]. As shown in Figure 6, a typical LiDAR sensor employing a laser in 905 nm of the near-infrared ray (NIR) region uses technology to convert the time-of-flight (ToF), which is the time difference between the transmission of the laser (t1) and its reflection from an object back to the sensor (t2) [9–10].

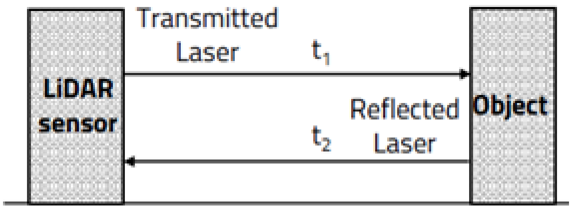

Figure 6: Time-of-flight (ToF) of laser

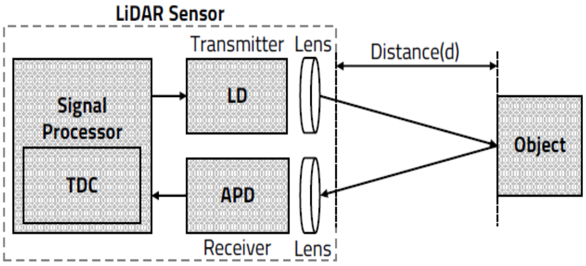

Figure 7: Structure and operation of conventional light detection and ranging (LiDAR) sensor

A LiDAR sensor, which detects the precise distance from an object by transmitting a laser, consists of a laser diode (LD), an avalanche photodiode (APD), a time-to-digital converter (TDC), and signal processing units, as shown in Figure 7 [11].

The LD transmits the laser, which is concentrated through a light-transmitting lens. The laser transmitted from the LD is reflected back from the thing and received by the APD through the light-receiving lens. The TDC measures the difference between the time the LD transmits the laser and therefore the time the APD receives it then converts the difference to the highest. The signal-processing unit, denoted by a microprocessor (MP), receives the ToF from the TDC and calculates the space between the LiDAR sensor and therefore the object. The laser of the LiDAR sensor are often classified into a pulsed, amplitude-modulated continuous-wave (AMCW), and frequency-modulated continuous-wave (FMCW) consistent with the transmission principle. The pulsed may be a method of transmitting a laser with an instant peak power employing a short pulse of several nanoseconds. Because the intensity of an instantaneous laser is strong, it is used for long-distance measurement. The AMCW may be a method of transmitting endless laser. The distance is measured by comparing phases of the transmitted and backscattered detected waves. Because it measures a phase shift of the transmitted and received laser, it is not suitable for an accurate distance and long-distance measurement [12]. The FMCW may be a method that compensates for AMCW's incorrect distance measurement. It transmits the laser continuously, but the frequency changes with time. The accurate distance measurement is feasible because the laser TRM are often known through the frequency of the received signal. However, it's structurally more complex than the AMCW and isn't suitable for long-distance measurement because the frequency changes thanks to the Doppler effect [13].

The types of LiDAR sensors that measure distance are categorized into scanning sensors, microelectromechanical system (MEMS) sensors, flash sensors, and optical phased array (OPA) sensors. Scanning and MEMS sensors use mirrors to spread the laser to detect multiple directions. Scanning sensors use a mirror rotated by a motor to change the angle at which the laser is reflected and transmitted [14,15]. MEMS sensors use the mirror to transmit the laser in the same way as scanning sensors, but the mirror is operated vertically, horizontally, or in all directions [16–17]. Flash sensors transmit one large-area laser, like with a camera , and receive the laser reflected by the thing in an array sensor, which is expressed in one frame [18,19]. OPA sensors use a method in which an optical phase modulator controls a phase of the laser through the lens and transmits the laser in various directions [20,21].

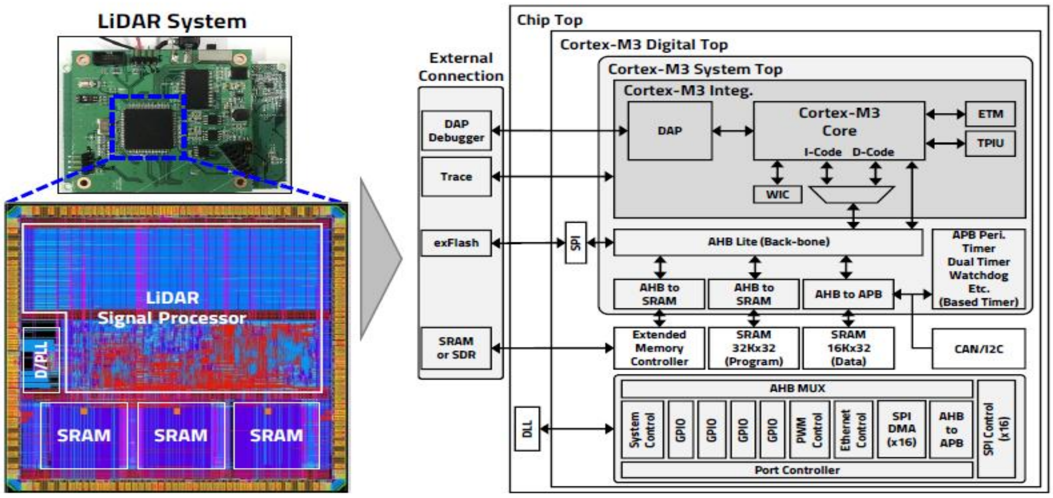

Figure 8: Designed microprocessor (MP) chip

This sensor is used to assemble on the tip of the blades and should focus the distance between the tower and the tip of the blade. This LiDAR is used to connect with the Arduino and then the data will be shared through the Wi-Fi module. A designed chip is shownin figure 8[22]

4.5 Wi-Fi Module

In proposed methodology we connect three Arduino modules and communicate using Wi-Fi module port configuration.

5. Flow Diagram

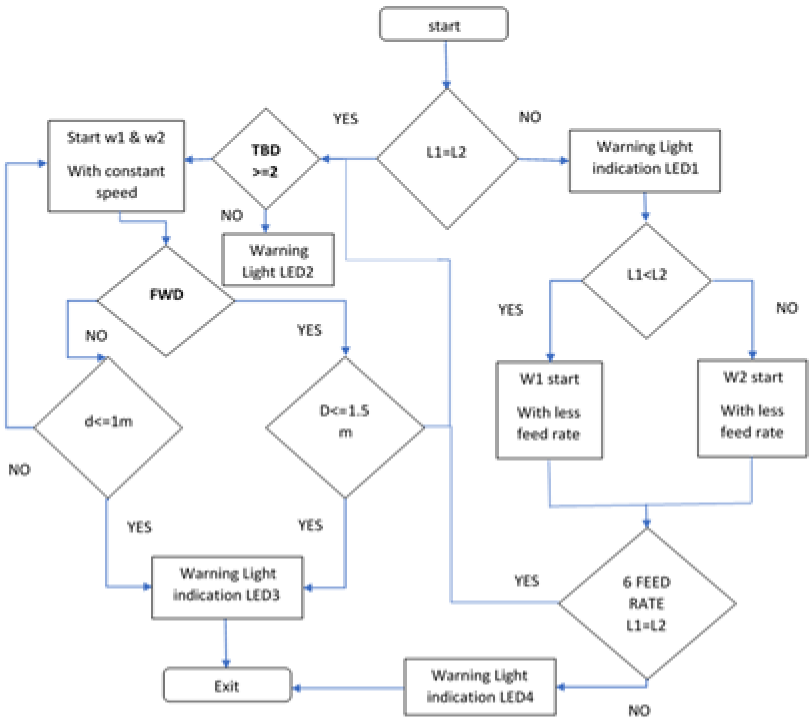

Figure 8: Flow diagram

6. State Machine Diagram

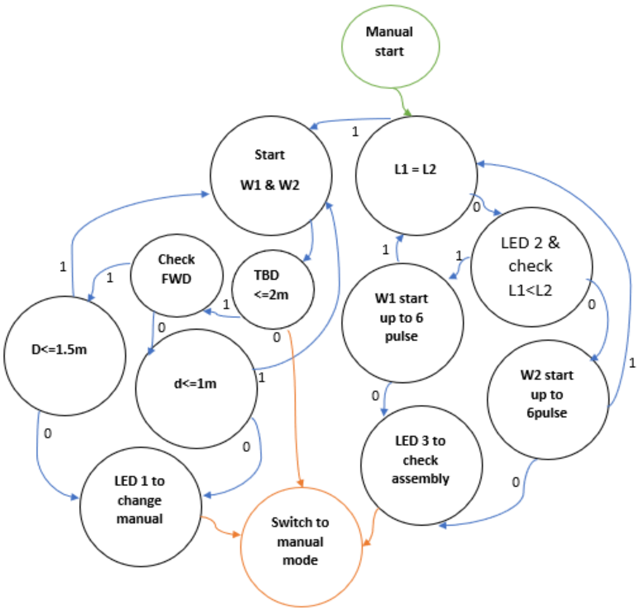

Figure 8: State machine diagram

7. Conclusion

With this semi-automatic operation, the chance for involving human error in the simultaneous operation of two winches can completely be narrowed. Also, the blade will be lowered or raised with an automatic alert generation whenever the blade tends to get out of the safe tolerance limit due to gusty wind during the operation. This set of semi-automatic operation will make the work-force to get rid of the complicated operations and the requirement for highly skilled winch operator's may also be bought down. As the erection process is marginally automated, with further inclusion of automation in future the entire operation may be automated to reduce the time consumption further.

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Author Profile

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