Team #10

Hoist Preventative Maintenance

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Mentors: Ralph Munguia

Customer Background

John Deere is a leading manufacturer for industrial vehicle systems for agriculture, forestry, and heavy machinery with high volume production facilities to accommodate it.

Problem Statement

The production process requires the ability to handle material in a safe and timely manner with a focus on maximizing uptime. To support this, the client seeks to implement a system for measuring usage and wear on the hoists used in production to shift from preventative maintenance to predictive maintenance.

Requirements

Three major factors were selected for the measurement of the hoist's overall status: ambient temperature within the motor casing, stability of the hoist itself, wireless accessibility, and orientation of the system in 3 dimensions. The accompanying sensors are a temperature sensor, an accelerometer, and gyroscope. The temperature measures the overall ambient temperature of the motor casing in degrees Fahrenheit, the accelerometer measures acceleration in the x, y and z directions in m/s and lastly the gyroscope measures the orientation of the Raspberry Pi in the same 3 axes (x, y, z) in degrees. Current measurements into the hoist were also considered during the design process, however the current system required a separate embedded system that had no wireless accessibility and therefore had to be subtracted from the final design.

Requirements Matrix

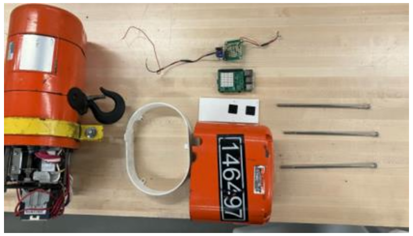
Req. #	DESIGN REQUIREMENTS	DESIGN TARGETS	VALIDATION	COMMENTS
	RATIONALE			
1	Measure temperature	Equip to hoist to accurately measure internal temperatures.	After high heat exposure internal components will send a signal to maitenance as well as locking system.	How many heat cycles does it take before damage will begin. How hot does an average cycle get. How hot before component failure or plastic melting.
	Client has pointed out on more than one occasion that hoist motors are having multiple failures points due to heat exposure.			
2	Keep design wireless	Keep extra wires off the production floor	Present a working system using wireless technology	
	During the meeting with John Deere, a colleague asked if the system in place was interconnected with other hoists. The local systems of each hoist can be hard to maintain and would benefit from any error popping up on one large main system.			
3	Prevent Side Loading	Ensure a system that prevents side loading	Try to side load material and have the system stop itself.	Measure the angle allowance before hoist will suffer damage from improper use. 0 deg to 15 deg for prelimary estimate.
	After interviewing John Deere it was obvious they were having safety issues with loading products at an angle instead of directly vertical.			
4	Make sure the motor or contact in hoist doesn't burn out.	Provide some sort of heat detection system within the hoist in order to keep things at a level temperature	By pushing the motor/contact past the safe range making sure that a safety check, or emergency turn off is in place	Continuity test to test which contacts are failing in order to isolate problem areas.
	It was made evident that due to human error many motors/hoists were either broken or the contact itself was blown. There needs to be something in place stopping from fidgety employees being a risk factor to the hoists.			

Experimentation and Concepts

Initial designs included the use of a non-invasive current sensor to add the functionality of current sensing into the system. While testing of the current measuring system was successful, the selected Raspberry Pi did not have the capability to accept analog information as an input. While it would have been possible to use a separate microcontroller and network it together with the Raspberry Pi, it ultimately fell beyond the scope of the project.

Some initial designs sought to implement a higher level of autonomy through the use of a more heavy-handed machine learning approach. While more independent machine learning algorithms did provide more autonomy, the implementation of these algorithms generated problems with the level of precision with which each unit could measure and respond to faults and was thus left at a lower level of autonomy.

Final Design



The final design implemented the factors identified in the design requirements. The Raspberry Pi was capable of measuring orientation, acceleration, and temperature with the use of the SenseHAT peripheral device.

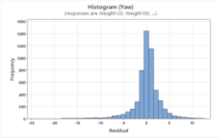
Testing

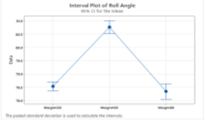
3 Phase Testing Sequence

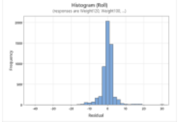
Phase 1: Software Functionality
- Debugging code was successful
- Data Collection
  - PI was able to pull values off the hoist and into one file for analysis
  - Mostly accurate findings
  - Pitch Data was inaccurate but not critical to side loading purposes
- Wireless Compatibility
  - SSH access is feasible

Phase 2: Sensor Functionality On The Hoist
- Mechanical and electrical components are not faulty – no breakage in either type

Phase 3: Output
- ANOVA Analysis used for comparing performance amongst different weight loads
- Roll and Yaw results below of critical plots to infer
- Email Notifications – sending proper fault type with associated graph (part of debugging phase which was successful)
- Example: Roll Angle was recorded too many times as side loading; plots all angle values over recent period of time including the magnitudes of the fault points (see below)

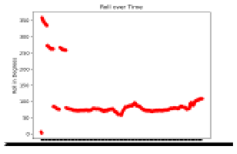






From: rapsberrypigroup10@gmail.com
Date: April 16, 2024 at 3:17:15 PM EDT
To: sullyeg@icloud.com
Subject: DEGRADED STATE: Roll

This hoist has detected that the Roll parameter has exceeded its allowed fault limit. Please update the tolerances and/or conduct maintanence.



Testing Setup (Sensor Inside)