Cloud Based Status Monitoring Of Earthmoving Machinery

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Abstract: Earth Moving Machinery is very expensive and is used extensively in harsh working environment. Therefore, it is imperative that the owners of the machines have access to the working status of the machines in real time. The OEMs of earthmoving machinery equipment provide a web based interface to their customers showing information such as on/off status, GPS location etc. The interface does not provide any information on some important aspects such as whether the machine is idling or digging when on and proper/improper handling of the machine by the operator. A study of vibration data fetching devices was carried out for selecting a low cost and reliable sensor and data acquisition system. ADXL 335 GY-61 accelerometer was selected for measuring the vibration data and Arduino Uno WiFi microcontroller board was chosen for fetching the vibration data from the sensor and uploading it to the cloud. A free cloud service cayenne.mydevices.com was used for displaying the idling and digging modes of the machine by correlating the machine vibration data with the respective modes. From the vibration data it was observed that during idling mode the average value in X direction was 650 mV/g in Y direction 660 mV/g and in Z direction 670 mV/g. However, during digging operation the corresponding values were 735 mV/g in X direction, 730 mV/g in Y direction and 610 mV/g in Z direction. Therefore, it was inferred from the vibration data that whether the machine is in idling or digging mode. An alarm feature was added to alert the operator and the owner of the machine through a message on his/her mobile phone in case a vibration value higher than 765 mV/g was measured by the system during digging mode.

Index Terms: Earthmoving Machinery, IoT, Vibration, Accelerometer

1 INTRODUCTION

Earth Moving Machinery apply to machines, attachments, and derived machinery designed for loosening picking up, moving, transporting and/or distributing earth, or to grade earth and rock. Digital transformation is driving the commercial vehicle transportation industry with mobile and wireless devices empowered by telematics and the Internet of Things (IoT) technologies. Interconnected telematics systems have contributed tremendously to the optimization of the commercial vehicle transportation industry. They have increased driving efficiency via real-time communications and by leveraging GPS and other navigation applications to direct drivers toward open roads and away from any obstructions that could cause delays. They have also helped reduce vehicle idle times and maintenance costs, increased driver safety and job satisfaction, and enhanced vehicle performance and security. Together, telematics and IoT technologies are changing the entire landscape of the commercial transportation industry, as well as every industry that is reliant on its vehicles to do business. New digital supply chains and ecosystems are coming together to create a global digital vehicle transportation business, and greater interconnection is making it possible. The data that telematics transmits can be quite extensive, but there are three items of data that just about every telematics package is going to provide: location, run time, and fuel consumption From location data you can detect equipment theft or misuse, figure out how many cycles it takes to complete a certain job, or tell a technician where to find a certain piece of equipment that is located in the maze of a massive construction site.. One of the areas of development that has a high impact on the construction industry is the use of wireless technology to provide connectivity for heavy equipment.

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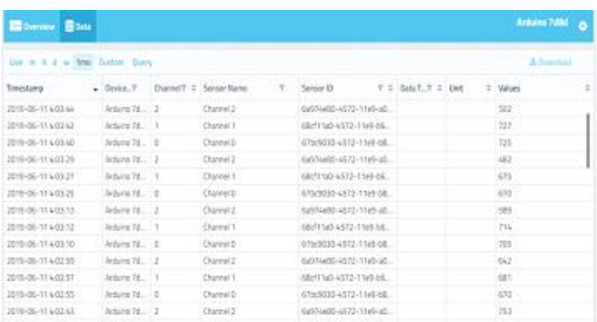
People have become accustomed to a high degree of connectivity in their daily lives, in large part due to the widespread use of tablets and smartphones. The connected construction machine uses these devices combined with cloud computing, allowing for the storage and sharing of data, as well as widespread access to information and services. Telematic solutions for remote monitoring of construction machinery have been available for several years; typically, it involved having a cell modem installed on the machine to provide Internet access. However, this approach requires each machine to have its own cell phone plan, which makes the cost of these solutions often higher than the benefit gained from remote monitoring. A more cost-effective approach tethers an Internet connection through mobile devices and makes use of the data plans already in place. This way, no separate cell plan is required for the machine itself, bringing down the cost for this functionality. IoT represents an exponentially growing technology that provides connectivity and functionality in the cloud environment. Combining this with wireless technologies, attractive options for construction machinery are possible in the areas of remote monitoring, M2M interfaces, data logging and theft tracking. Customized apps can be easily developed for any platform, integrating smartphone features, such as GPS, weather and maps, and used to interface with the vehicle control system. Wireless technology brings exciting capabilities, and the use of its features should improve and enhance the vehicle control system, which remains the primary focus of functionality and productivity. Networks of controllers, sensors, actuators and displays should work together to provide the desired functionality for construction equipment and to improve its performance. Perhaps the most important aspect that ties all of the vehicle technologies together is the software that runs on each electronic component. Software allows designers to customize the behavior of the equipment to implement features, improve performance and provide the desired “feel” of the machine. Since the software is usually customized for each application, this can be the differentiating factor that brings value to one machine over the competition. While software development for construction machinery can be challenging, the benefits far outweigh the efforts.

2 EXPERIMENTAL DETAILS

The first step was to study the devices that are being used on the JCB JS205 machine for the data exchange. In this step, the identification of devices on the machine and to know the compatibility of the device with other external sources to gather the data. The JCB JS205 machine has Pricol made telematics device which is controlled by jcblivelink.inExtensive use of jcblivelink.in and Cayenne.mydevices.com software for controlling Arduino devices remotely for real time monitoring of health and performance of machine and for predictive capabilities and security of machines remotely. jcblivelink.in gives information about machine location, machine working hours, engine status whether it is on or off, battery information, engine coolant temperature, engine oil pressure level, service due warning. Customer Id of Nav Durga Stone Crusher Pathankot Punjab is used. Here no information on vibrations produced is given so to get vibrations values at our end GY61 ADXL 335 sensor connected to arduino uno wifi was used with programming it with cayenne.mydevices.com to access the vibrations produced in the machine. Dashboard of cayenne.mydevices.com is used to get the values of vibration produced. cayenne.mydevices.com is a software for monitoring solutions. It provides solutions to monitor devices remotely while sitting anywhere in the world hence making it easier to control devices easily and efficiently. It also acts as a warning giving device in the areas of inaccessible human reach. It provides various services for computation, storage, database, networking and IoT. It accelerates IoT development and empowers enterprises to quickly design, prototype, and commercialize IoT solutions. It is world's first drag and drop IoT project developer.



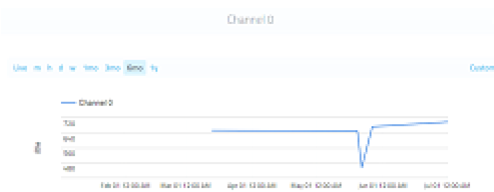
The vibrations calculated on GY61ADXL 335 sensor is measured in X, Y, Z directions. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration Vibrational data from JCB JS205 was acquired by the GY-61 ADXL 335 sensor installed on JCB JS 205 paired with Arduino Uno plus Wi-Fi programming it feasibly with cayenne.mydevices.com. The operational data was measured on site of working of JCB JS 205 earthmoving machine of NavDurga Stone Crusher Pathankot Punjab. Machine vibrations were measured when idling and during digging operation. Comparatively vibrations produced during digging were high according to earth strata. When strata of earth during digging was hard there were much vibrations produced which was calculated with GY61 ADXL 335 sensor on Arduino Uno with Wi-Fi programmed with cayenne.mydevices.com where whole vibration values in X, Y, Z directions values were shown on the dashboard. A local hotspot was given to access internet. A limit was set onto 740 mV/g value above which a message was received by the owner informing of the threat of more vibrations being produced.

The Data was then uploaded to cloud at cayenne.mydevices.com. For this an account on cayenne.mydevices.com was created which is a free service. Cayenne.mydevices.com provides various services for computation, storage, database, networking and IOT. Mydevices.Cayenne.com provides simplified and accelerated IoT development. MyDevices.cayenne.com is an Internet of Things solutions company. It accelerates IoT development and empowers enterprises to quickly design, prototype, and commercialize IoT solutions.

3 RESULTS & DISCUSSIONS

The vibration data sensed by ADXL 335 accelerometer was acquired by execution of a programme for the controller using the software Arduino 1.8.3 in Arduino microcontroller. The microcontroller has WiFi installed by which the data was streamed to internet site mydevices.cayenne.com to get the vibrations produced during idling and digging operations on cayenne.mydevices.com

Idling Operation – In idling operation only the engine of the machine is on and it does no work



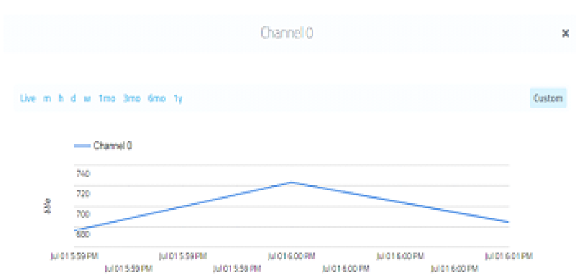
(a)

(b)

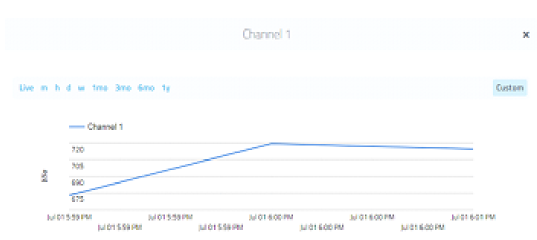
(c)

Time History Of Vibration in (a) X Direction , (b) Y Direction, (c) Z Direction during IDLING

Digging Operation – In digging operation the microcontroller with GY61 ADXL 335 sensor records vibrations produced and send it on the cloud with the programme in it. The values produced were displayed on the dashboard of mydevices.cayenne.com. Digging operation let us know how the machine is performing. The vibration analysis let us know about the strata of the earth on which the machine is digging. More harder strata more the vibrations are produced during the impact stroke of the machine bucket which produces more vibrations than idling operation of machine hence an indicator that machine is working in hard conditions. During digging it was also noted that the boom of the machine produce more vibration when digging is being executed rather than during idling operations. Digging in deep pits also produced more vibrations as compared to digging on normal earth surface. The vibrations produced were high than the earlier digging operations and those in shallow waters. The earth strata goes on getting harder as we dig deep, hence vibration analysis helps us know the exact condition monitoring of machine. jcblivelink.in could only describe whether the machine is on or off, but this study will help in extracting information regarding the working condition monitoring of machine with the help of vibration analysis and the values we get in executing whole experiments on site of working of JCB JS 205 LC machine.



(a)



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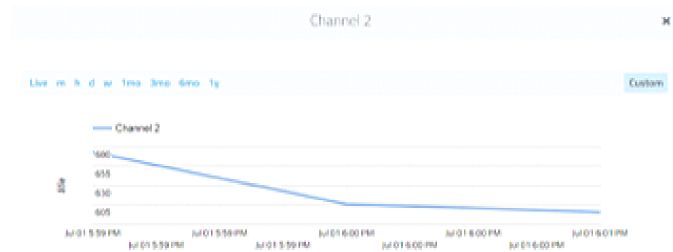

(c)

Time History of Vibration in (a) (X Direction), (b) (Y Direction), (d) (Z Direction) during DIGGING

The above data received describes about vibrations produced during idling and digging operation. The data analysis let us know about the predictive condition monitoring of machine during its working. During idling as per the recordings in x direction the value remains constant till 650 mV/g, in y direction 660 mV/g , in z direction 670 mV/g, but during digging the values changed i.e in x direction 735mV/g, in y direction 730 mV/g and fall in z direction 610 mV/g . The change in vibration let us know about the machine actual working.

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4 CONCLUSION

The real status of the JCB JS 205 LC earthmoving machine can be accessed remotely on OEM maintained web-based interface jcblivelink.in but additional features based on low cost vibration monitoring have been added in made system from which following conclusions are drawn on the basis of experimental work and analysis of the result.

- A low cost cloud based status monitoring system was successfully made using commonly available vibration sensor, microcontroller and freely available cloud service.
- ADXL 335 GY-61 accelerometer vibration sensor was used to measure the vibration of the JCB JS 205 LC machine in X, Y & Z directions in idling and digging modes.
- Arduino Uno WiFi microcontroller was used to acquire the vibration data from accelerometer and uploading the same to free cloud service cayenne.mydevices.com.
- The vibration data in X, Y&Z direction was successfully uploaded to the cloud at an interval of 40 seconds which is more than sufficient for the condition monitoring of JCB JS 205 LC machine.
- Whereas the OEM web-based interface jcblivelink.in provides on/off status of the machine, it was possible to determine the idling and digging modes of the machine based on vibrational data. Further the vibration data was also used to sound an alarm in case of excessive vibrations in digging mode.
- JCB India Ltd. can provide predictive condition monitoring facility to it's customers by using the approach proposed in the present work. The data can also be used for providing additional information like fuel consumption to the customers.

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