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THE USE OF A GYROSCOPIC SENSOR FOR DETECTION OF A BRIDGE COLLAPSE

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ABSTRACT
In today's world there are a lot of recent hazardous events due to collapsing of bridges. Due to over weighted vehicles and due to turning of those vehicles at a high speed at some proper weak points of the bridge, the bridge can vibrate a little which crosses the threshold value. This excess amplitude of vibration can predict if the bridge id in danger or not. This small scale vibration is not perceivable by human, but it can be detected by the sensor. The project not only just read the vibration data. But it also do some computations to determine the bridge is in danger or not. Then it sends the error report to a remote server using a HTTP request from a local device. Then it also sends the error report as a Simple Messaging Service (SMS) to a pre-registered phone number.

Keywords:
ATMEGA328P-PU; MPU6050 3axis Gyro+Accelero Sensor; Android mobile with Local Server app;

INTRODUCTION

Every bridge has a capacity about the maximum weight of vehicle it can allow to pass. There is always vibration in bridges which is not perceivable by naked eye. But there is a facility in our project with which it is possible to graphically monitor the vibrations in a computer when it is connected to the microcontroller with serial communication. This plotting program shows the plot in soft real time. This plotting system runs only locally because normally this is not required always to constantly monitor it by a human. The MPU6050 actually senses the accelerometer data along three axis and converts to a digital sampled form,then sends it to the controller through I2C connection discussed later. The controller sends the data to a local device by TTL WLAN connection using HC-05 Bluetooth module. The local device my be any comuting system having internet connection, like a dedicated android mobile or a computer. This local device receives the gyroscope data and then decides if the data is abnormal or excessive vibration is occurring then it receive image fram from a camera and sends the image alsong with the sensor data with date and time of incident, to a remote server. The data submitted to the server can be seen through an online website where only authenticated users can enter. The project doesn't consider the actual preventive measure, but it helps to detect those bridges which are prone to collapse. After appropriate preventive measure the log can be cleared through the same website.

HARDWARE

The project has been developed using ATMEGA328P-PU micro controller unit, MPU6050 3axis accelero+gyro sensor, HC-05 Bluetooth module, local device possibly an android having camera facility or a small computer having usb camera.

A. ATMEGA328P-PU:-
It is a 28 pin IC package. Its pin diagram is shown below.

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Now the pins which we are mainly interested in are listed below.

- SCL/ADC5/PCINT23 or PIN 28: It is the synchronizing clock signal pin for I^2C serial communication between the MCU and the accelerometer sensor.
- SDA/ADC4/PCINT14 or PIN 27: It is the data bus pin for the same I^2C serial communication between MCU and the accelerometer sensor.
- PIN 4: This pin actually is used for the interrupt signal.
- PIN 5 and PIN 6: These digital pins are used as RX and TX respectively for the TTL communication between the MCU and the HC-05 Bluetooth module. These are connected to the TX and RX of the module respectively.
- The pins 2 and 3 are used for the serial communication between the MCU and the local terminal computer (if it is present) for plotting the data mainly for threshold setting.

B. MPU6050 3 axis Gyro+Accelero:-

The pin-out of this module is below. The interface is explained.

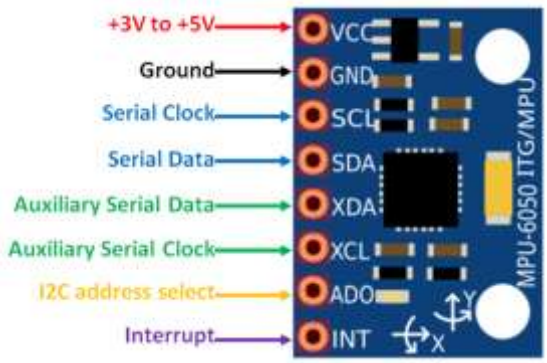

Fig. 1: MPU6050 3 axis Gyro+Accelero

The communication between the MCP and this module is through the I^2C serial communication. So standard I^2C data bus SDA is connected to the SDA or the MCU(Micro Controller Unit). And the I^2C clock signal pin in connected to the SCL pin of the MCU. It gets a regulated power of about 3.3v.

It has a good number of features like

VDD Supply voltage range of 2.375V–3.46V; VLOGIC (MPU-6050) at 1.8V±5% or VDD, digital-output of 6-axis MotionFusion data. 9-axis fused data from Motion Processing Library, tri-axis angular rate sensor (gyro) with a sensitivity up to 131 LSBs/dps and a full-scale range of ±250, ±500, ±1000, and ±2000dps, tri-Axis accelerometer with a programmable full scale range of ±2*g*, ±4*g*, ±8*g* and ±16*g*, Reduced settling effects and sensor drift by elimination of board-level cross-axis alignment errors between accelerometers and gyroscopes, Digital Motion Processing (DMP) engine offloads complex MotionFusion, sensor timing synchronization and gesture detection, Accel low power mode operating currents: 10µA at 1Hz, 20µA at 5Hz, 70µA at 20Hz, 140µA at 40Hz, Smallest and thinnest package for portable devices (4x4x0.9mm QFN), RoHS and Green compliant. These features are extremely helpful for this embedded system project.

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C. HC-05 Bluetooth Module:-

FIGURE 2 :HC-05 Bluetooth Module.

It is interfaced with arduino through. It is driven by a regulated supply voltage VDD of 3.3 volts. It receive the data to be send in serial manner from the MCU through the TTL serial TX/RX line. It converts the serial data to RF signal of frequency between 2402 and 2480 MHz. Its default baud rate is 38400 and supports 8 data bits per frame with 1 stop bit. This data is read by the local device. Which acts as a decision maker, and it is placed inside the Bluetooth coverage are by the module.

D. Local Device:-

This is basically a host, which is typically a device running android OS, as an app is responsible for all the decision making functionalities. If excessive vibration occurs then this app will send an SMS to a pre-registered mobile number. Then this app will also send an HTTP request to a server and it will upload all the information about the event, like date and time of the event, location of the bridge(each bridge is distinguishable by this) and also the footage from the camera. These data will be stored in the website.

E. Optional Computer(Processing):-

During initial placement it may be required to set appropriate limit for the maximum tolerable vibration amplitude. So a plotting program is written for this purpose, which will plot the real time 3 axis accelerometer data in a single graph using 3 different colours so that 3 axis accelerometer reading can be distinguished and threshold can be set depending on the pattern of the graph.

SOFTWARE

A. Remote Server:-

It is basically a online/hosted
web site which is hosted by Apache server. The server sided code is written in PHP(Pearl Hypertext Pre-processor). This includes an authentication system so that only authenticated users can view the data. The user registration system will not be online, it may be made online temporarily, or new users can be added using an application software .

B. DBMS system used:-

We are using MySQL for storing all these report data. It is easily compatible with PHP language and both are completely free, so that there is no additional cost incurred by this.

C. Plotting software:-

It is a software written in java using a popular library named Processing. It can plot the real time accelerometer data. It requires java interpreter(JRE) and the processing library which are free. It is cross platform supported. It can easily run in Windows, Linux, Mac etc.

D. Android App:-

It is an android app which receives the gyroscope data through Bluetooth from the MCU unit. It then checks if the vibration is more than normal value. If it is, then it sends an alerting SMS to a registered phone number and also upload data with the camera frame to the server using HTTP request.

WORKING PRINCIPLE

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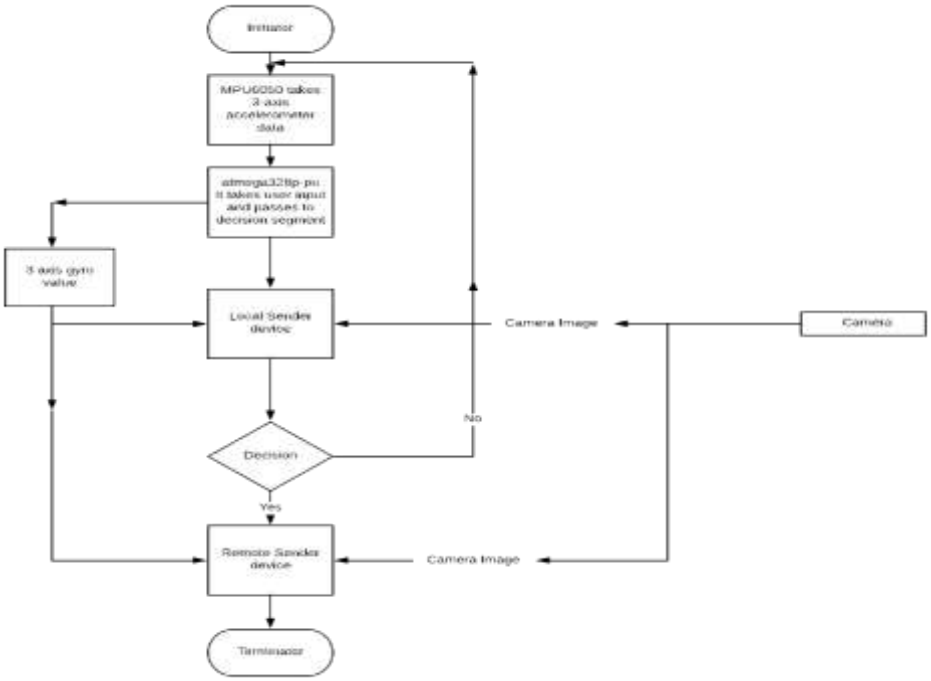
The central part of this system is the accelerometer sensor. It detects the 3 axis accelerations at the point of implementation. The data is read by the microcontroller atmega328p-pu and its in-built ADC(analog to digital converter) converts it to a 10 bit binary value(decimal 0-1023). This digital encoded value is used in the else parts. The controller then sends these 3 data to the two pair of serial TTL ports i.e. pin2&3 and pin5&6. The pins 2&3 are used by the optional local plotting machine, which may be connected to it via a USB to serial converter. The other serial connection is used with the Bluetooth module. The module sends the mandatory local machine running the pre-built android app. The app checks if the obtained vibrations are not normal. For vibration above the threshold this device will send an alerting SMS to a registered phone number and also upload data with the camera frame to the server using HTTP request.

V. BLOCK DIAGRAM

The flowchart of the system is as follows.



RESULT

This system will be implemented in the middle of centre span/critical span. The accelerometer is very sensitive, so it can sense the small scale vibration in the bridge. There is no need for a human on the spot, this is fully automatic. The local device should be LAN connected using Bluetooth, so it should be inside 10 meters from the module. Because the range of HC05 Bluetooth module is 10 meters. Now this range can be increased by moving the HC05 module far apart the microcontroller unit by serial Ethernet connection, near the local device (for long bridges having a single local device). For this long bridge scenario, if more than one sensor is involved, then, all these sensors will be connected to a central common microcontroller unit. Which sends all the data from different sensors in a burst to the local sender. The local sender distinguishes between them. So, there is a mode in the app, through which it can be configured for the different modes, like 2sensor mode, 3 sensor mode, etc.

CONCLUSION

Human life is of great importance. Due to difficulty of maintenance of bridges a lot of events of bridge collapse throughout the world are taking human lives. This project can help the maintenance team to easily monitor the different bridges in a particular region.

Depending on the error reports the concerned maintenance can take quick preventive measure to prevent its collapse.