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Road Condition Monitoring with Grading System

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Abstract: *India has the highest number of two-wheeler riders in the entire world. As Indians think that two-wheelers are more convenient a lot of people use them for their daily activities. Delivery boys for a lot of companies also prefer to use a two-wheeler as it is more economically convenient. Along with this, people also use two-wheelers for rushing to the workplace avoiding a lot of traffic. The majority of these people can be classified as young adults. A lot of people complain about back issues due to the bad road conditions that they face while travelling every day. Our system uses the sensor consisting of the accelerometer and the gyroscope to analyze the condition of the road and classify how bad the current condition of the road actually is. The system will not only classify the road as good or bad but also provide a rating to the road based on how severe the condition of the road actually is. The sensors will be calibrated according to a particular vehicle which will be beneficial for the rider. The system will also provide the best option of the road from travelling from point A to point B provided if there are multiple options available and the analysis of all the options has been done previously.*
Keywords*: Machine Learning; Road Conditions; Impact Analysis*

I. Introduction

The idea of this system was raised due to the immense increase in the number of bad roads and the consequences of the impacts caused due to the impairment of the roads on the human body as well as the vehicle. This is mainly due to the lack of proper equipment to monitor the condition of the road. Maintenance of these kinds of roads becomes time-consuming and a tiring task as tracking of these bad road conditions is a major problem. This also leads to various other problems like affecting the health of the person who's driving due to the whole-body vibrations. The back plays a crucial role in a human body and that's one of the main body parts getting affected due to these conditions.

Our system classifies the roads on the basis of the irregularities present. It classifies it into 5 different categories on the basis of the road condition.
Our system is made to counter these adverse effects on the human body and mainly focuses on creating a platform for the government bodies to see which roads are in bad condition and provide maintenance accordingly. This system is based on two-wheelers as many individuals drive these vehicles to avoid traffic and especially in India the people riding two-wheelers are more. Along-side this two-wheelers are the ones which are most impacted due to these bad road conditions.

Due to this system, proper road conditions can be maintained along with that vehicle maintenance costs will reduce as the impact the vehicles will take will reduce at a greater extent due to good road conditions.

II. Related Work

Jakob Eriksson, Lewis Girod, Bret Hull, Ryan Newton, Samuel Madden and Hari Balakrishnan[1] made the idea relevant about how the sensors can be used within a vehicle to classify the road conditions. The irregularities on the road such as different types of holes such as potholes, manholes etc can be easily identified using this. This information can be useful for the government to keep track of the roads.

Artis Mednis, Girts Strazdins, Reinholds Zviedris, Georgijs Kanonirs and Leo Selavo[2] came up with the idea that the accelerometer present on the smartphones can be useful in determining the condition of the road. The condition is determined based on the calculation of the Z-axis threshold value with the true positives being as close to that of 90 per cent.

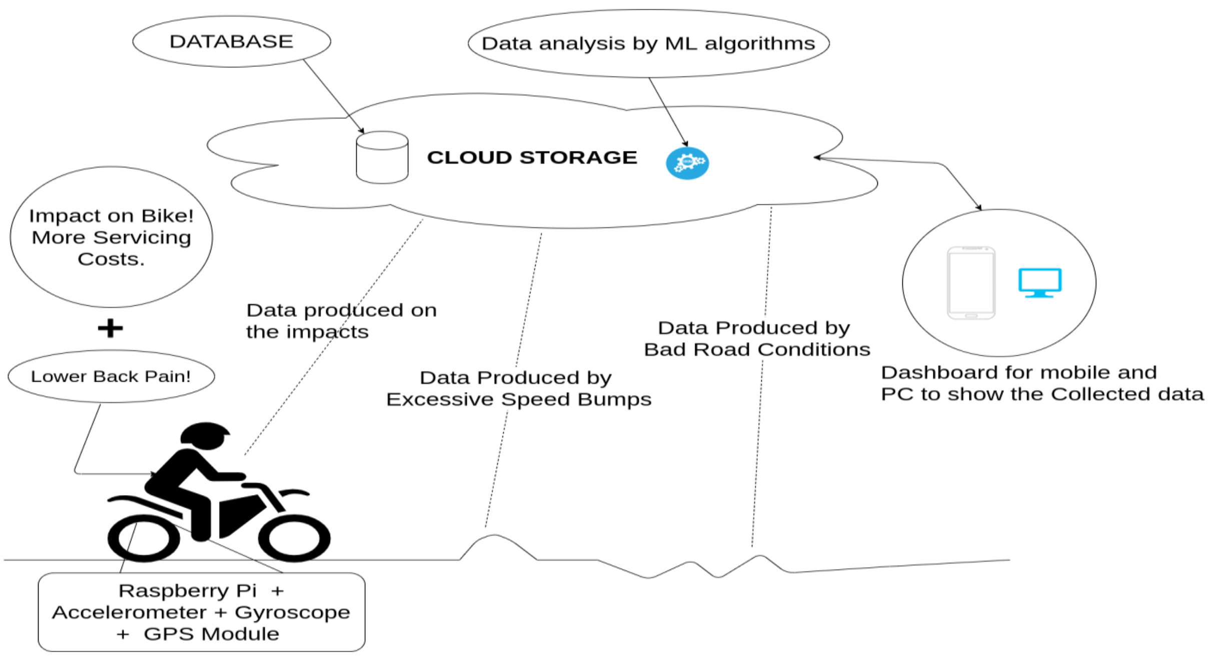
Umang Bhatt, Shouvik Mani, Edgar Xi and J. Zico Kolter [3] researched a method where we can classify the condition of the road efficiently based on the number of potholes present on the road. They calculated the standard deviation using the values obtained by the accelerometer. These values that are obtained can determine the level of damage that has been done to the road. Using this method the best road from a point to another can be found out.

Shivakumara BS and Sridhar V [4] performed a number of experiments to determine how the Hand-Arm Vibrations (HAV) and Whole Body Vibrations (WBV) can cause damage to the body while driving a motorcycle. They were also successful to determine the correlation between the frequency of vibration and the types of effects that can damage the human body to a certain extent.

Jaimon Dennis Quadros, Suhas P and Vaishak N. L. [5] analysed the variation of displacement of the various body parts for different terrain amplitudes and concluded that terrain amplitudes become ineffective above 8Hz frequency. They also concluded that the ideal speed for the head, back, torso and thorax is 31 km/h and it is 49.60 for the diaphragm, abdomen and pelvis.

Hsieh-Ching Chen, Wei-Chyuan Chen, Yung-Ping Liu, Chih-Yong Chen, Yi-Tsong Pan [6] performed an analysis of the predictions of the various health risks that the motorcycle riders are prone to. They gave a conclusion on a lot of factors such as ageing, Bone problems along with the Whole Body vibrations. The vehicle speed also results in the Vibration peak distributions.

III. Proposed Methodology



The hardware components that consist of the raspberry pi device and all the required sensors will be installed on the motorcycle. The data that will be collected using sensors will be sent to the cloud platform for further the analysis. The cloud will already have the pretrained algorithm where the training will already be performed using our algorithm from the data available. Using this trained model the particular road that the user is currently driving on will be classified. All this information will be provided to the user on the mobile application.

The working of the system is divided into 3 independent phases: Data Collection Phase, Data Analysis Phase and the User Interaction Phase. Using these three different phases we can easily track the development and the working of the project.

3.1 Data Collection Phase

In this phase, the actual data that is needed to train the algorithm will be gathered using the hardware components that have been installed on the motorbike. These physical components consist of Raspberry Pi, Accelerometer sensor, Gyroscope sensor, Pressure/Force sensor, GSM card and a casket to cover the Raspberry Pi. All the sensors will be connected to the Raspberry Pi and the information to the cloud platform will be sent to the cloud using the GSM card in the Raspberry Pi. The power supply to the Raspberry Pi will be given through the battery of the motorbike.

The data collected from the sensors will be 3 axis data that will be distributed and some more new features will be extracted which will be also helpful for the analysis.

The casket consisting of the raspberry pi will be calibrated using the bike type and the sensors will be placed on the shock absorber i.e suspension for further collection of the readings of the Z-axis. In the future, if needed more sensors can be added for more precise collection of the data.

3.2 Data Analysis Phase

As mentioned previously, the data collected from the sensors will be first transferred to the cloud platform for further analysis. The algorithms will also be deployed on the cloud platform as well. The algorithm that is used on the cloud platform is the Support Vector Machine commonly known as SVM which will make the classification purpose much easier into different categories that we are actually planning to do.

As the Support Vector Machine uses hyperplanes for classification it provides better classification results compared to any other supervised learning algorithms such as Decision trees or K-Nearest Neighbours. Also tuning the model is easier in the Support Vector Machine because of a parameter called a kernel. It basically helps you to determine what kind of data is provided and what will be the most efficient way to transform that. The kernel that we have used in the implementation of this project is the Gaussian Kernel.

The disturbance on the road will be provided by the gyro-accelerometer sensor. We will get the following data from the gyroscope g_x, g_y and g_z that is the data collected on the three-axis that is the X-axis, Y-axis and the Z-axis. Similarly, we will gather the data by the accelerometer for the three axes which will be denoted by a_x, a_y and az. Additionally for fetching some new features we added some newly processed data as well such as the dot product of $|a_x|*|a_y|$, $|a_y|*|a_z|$, $|a_z|*|a_x|$. Similarly for the gyroscope data also we added some new dot products that were $|g_x|*|g_y|$, $|g_x|*|g_z|$ and finally $|g_y|*|g_z|$. This newly processed data helped in achieving better road classification compared to that when used only the raw accelerometer and gyroscope data that is “$|a_x|$”,“$|a_y|$”,“$|a_z|$” and “$|g_x|$”,“$|g_y|$”,“$|g_z|$”

Using all of this data that is gathered and processed we can get the condition of the road. Along with all this data, we will also get the coordinates that are the latitude and the longitude of the road on which the user is travelling on. Using these coordinates the user can plot these coordinates on the map where the road condition will be much easier to visualize. This will also help the user to find the best road available with less number of potholes from one point to another. So, in the end, we will have two classifications, whether the road has potholes or not and if it does have potholes then the intensity along a scale of 0 to 4 and the second will be the best route containing less number of potholes.

The data will keep on updating, so the more the users collect the data along with the coordinates to plot on the map. This will be not only useful for the users but also the authorities to keep track of which roads need maintenance. And as the road conditions keep on changing from time to time the data will be updated as well and it will keep on reflecting on the maps. There will be different colours for plotting the potholes on a map. Example: Grade 0 pothole will have a different colour, grade 1 will have a different colour and so on which the user can change accordingly.

3.3 User Interface Phase

This is the final implementation of the project. In this phase, the user will be provided with an android application where the user can see the analysis of the road he has driven or where he is going to drive now.

Also, A proper dashboard is provided to the authorities where they can track the condition of the roads when the data of a particular road becomes available. The condition will keep on updating on a frequent basis. This will give an idea about what roads need maintenance.

The user app will constantly fetch the data from the updated cloud. It will also provide visualizations in the form of graphs as well as proper map plottings.

IV. Analysis of Impact on Human

Driving a motorcycle has more risk than driving a car. Also, the driver while driving a motorcycle experiences a lot of vibrations and bad road conditions can make the condition worse. It can adversely affect the body conditions as researched by Shivkumara BS and Sridhar V[4]. With this research, we can predict the extent of the damage that can be caused to the body due to the vibrations.

Similar research was carried by Jaimon Dennis Quadros, Suhas P and Vaishak N. L[5] where they found out the relation between the displacement and the frequency and the effects that they caused on the different body parts as well. They also provided an ideal speed where the vibrations experienced by the two-wheeler rider is just 8 Hz which is quite less. All this research can be implemented in our and the target of road analysis along with user satisfaction can be easily achieved.

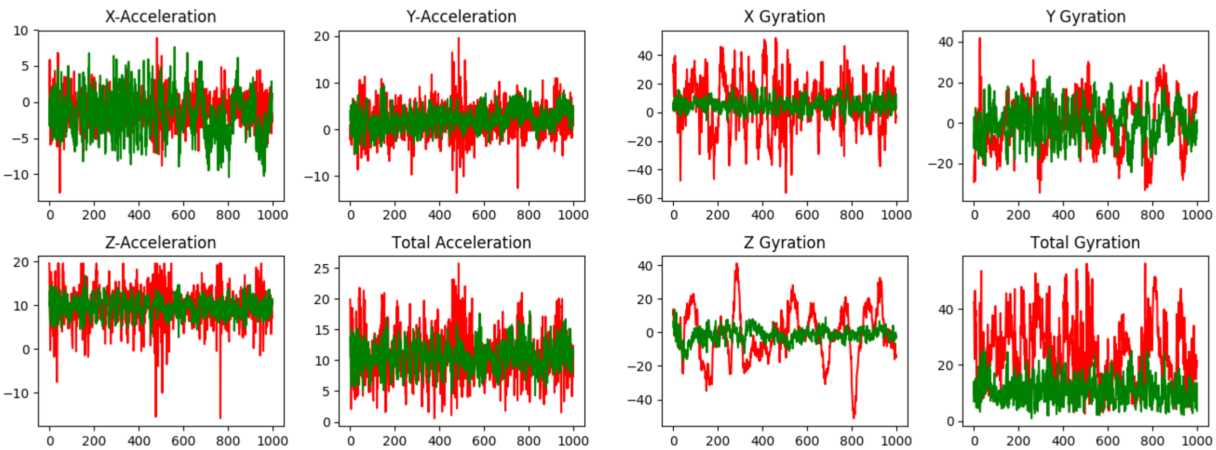
V. Results and Implementation

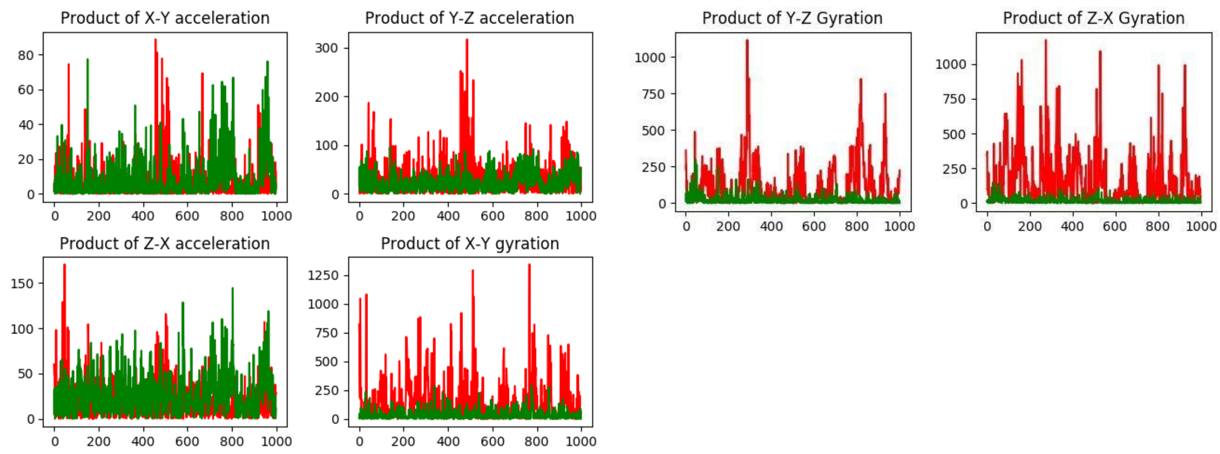
After collecting the dataset, we get the 3-axes data of Accelerometer and Gyroscope as mentioned above as these features won't suffice and could not be able to lead to proper classification we went with the method of feature selection and then found the correlation of those variables with the target variable that is the road condition class.

The parameter list became:

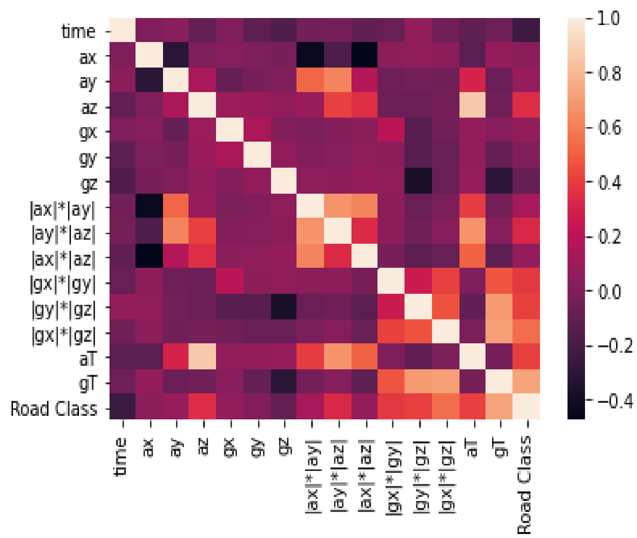
- a_x = X-axis acceleration
- a_y = Y-axis acceleration
- a_z = Z-axis acceleration
- g_x = X-axis gyration
- g_y = Y-axis gyration
- g_z = Z-axis gyration
- $|a_x|*|a_y|$ - Product of X and Y Accelerations
- $|a_y|*|a_z|$ - Product of Y and Z Accelerations
- $|a_z|*|a_x|$ - Product of Z and X Accelerations
- $|g_x|*|g_y|$ - Product of X and Y Gyration
- $|g_y|*|g_z|$ - Product of Y and Z Gyration
- $|g_z|*|g_x|$ - Product of Z and X Gyration
- a_T - Total Acceleration
- g_T - Total Gyration

The analysis graphs:





Correlation Matrix

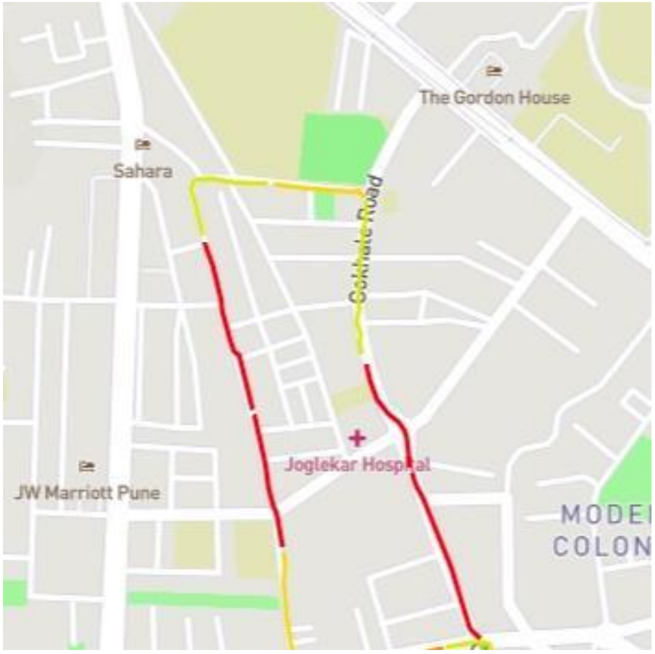


After analysing the graphs and the correlation matrix it was seen that the features “az”, “|ay|*|az|”, “gx”, “gz”, “|gx|*|gy|”, “|gy|*|gz|”, “gz|*|gx|”, “aT”, “gT” are the features more suitable and correlated with the “good” and “bad” road conditions.

After selecting the proper features the SVM algorithm was used to prepare the model to classify the road conditions accordingly.

Connections between the Raspberry Pi and MPU6050 unit i.e the Accelerometer-Gyroscope combined unit sensor is made with a server where location-wise data is stored and the classification model classifies the data.

After plotting the classified points on a maps API it looks like this



	Class 0
	Class 1
	Class 2
	Class 3
	Class 4

VI. Conclusion

We have implemented this idea as explained in this paper where we can analyse the discomfort that is being experienced by the user while driving a two-wheeler. The road classification accuracy of the model that we created is around 85 per cent and we will be looking forward to increasing it in the near future by adding some more parameters and some more model tuning.

This system helps the user to find the best available road to travel from one point to another. Also, it will be very useful for the authorities as well to keep proper track of the road conditions.
two-wheeler on the road and also predict the optimal speed at which the user should drive to avoid any effects from the WBV i.e Whole Body Vibrations experienced by the user.

This system will help the user to drive optimally and also the authorities can monitor the road conditions due to the classification provided by the system.

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