Road Roughness Analyzing System

5th Semester

Mini Project Report

Supervised By

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Candidate's Declaration

We hereby declare that the work presented in this project report entitled "Road Roughness Analyzing System", presented as 5th semester mini project is our original work carried out before Mid-Semester examination 2017-2018 under the guidance of Dr. Vijay Kumar Chaurasiya. Due acknowledgements have been made in the text to all the frameworks and resources used.

Signature:

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Dated:
September 18, 2017

Supervisor's Certificate

This is to certify that the project work entitled "Road Roughness Analyzing System" Submitted under my supervision and guidance partially for 5th Semester Mini-project work is a bonafide work of Vaibhav Agnihotri (LIT2015007), Mudit Rathore (ICM2015502), Mudit Dubey (LIT2015006).

This report is never submitted elsewhere for any other purpose.

Signature:

Dr. Vijay Kumar Chaurasiya

Date: 18th September, 2017

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Acknowledgement

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Abstract

As the condition of the roadway is decreasing day by day, the movement on the paths are getting difficult. So, we need an advanced multifunctional measuring device. The device must be used for road analysis and to get prediction of road behavior. The device is called the Road Roughness Analyzing System (RRAS) which enables cost-efficient and rapid collection of consistently reliable information about roads. The device measures several roadway conditions simultaneously, analyzes friction at the driving surface, provides video logs for the road survey, geometrical characteristics, etc. The information obtained is further processed.

After gathering all the required information through various sensors and cameras and performing measurements and tests we get the current condition of the roads as well as rut/crack positions which will be further processed to be updated on map data.

1. Introduction

1.1. Overview

The road roughness analyzing system is used to obtain the condition of various roads or paths. The device is used for road analysis and to get prediction of road behavior. It enables cost-efficient and rapid collection of consistently reliable information about roads.

1.2. Motivation

The degradation in condition of matter of concerned. It has become difficult to travel leading to wastage of time and energy resources. Various unsuccessful steps have been taken in this field but the scope getting wider and wider. We are interested to work in this field and to solve this growing problem.

1.3. Scope

There are many travelers on a network of roads in India. The travelers suffer great difficulties in traveling due to roughness and below standard condition of roads and taking this in account and thus this is a very good field to access.

2. Objective

The project aims to make an IOT (Internet of Things) based project in which the device will analyze the condition of roads in terms of roughness and give all the information about the surface defects during road survey for cracks characterization and detection. The objective is to develop Road Roughness Analyzing System for fast and reliable analysis.

3. Literature Survey

An IEEE Project has also been made with the similar aim which basically focuses on Image Based Automation. The plan of action for the project was the first, the road areas which include cracks are extracted as crack images analyzing the pixel variance of the road image. Then cracks are extracted from crack images by introducing a method on discriminant analysis.

It was a two-step pattern recognition system in which first detection of image blocks containing cracks is addressed and then cracks are characterized into type.

This system involves various hardware units and the mobile platform. The first results were about creating the digital road surface model and detecting the cracks on the roadway. The roads have to be classified into various categories. Therefore, the resulted digital surface model has to be transformed into basic numeric form. IRI (International Roughness Index) was used to represent the condition of the road.

4. Proposed Approach

We divided the work into following steps: -

1. Data Collection through various devices mounted on the vehicle system.
    a. Camera
    b. Laser sensors
    c. IMU Unit
    d. GPS System
    e. Accelerometer
2. Measurement through various measuring subsystems.
3. Data processing through computer system.
4. Computation of various roughness indices.
5. Verification.
6. Updating data on Map.

5. Requirements

5.1. Data Required-

We require a digital video for the virtual view of the road and the images for the analysis of road condition. In order to calculate the depth of cracks, roadway rutting as well as Estimated Texture Depth we also require a Laser Profilometry which would be synchronized with the digital video.

Combination of gyroscopes and software will provide us the measurement of vertical alignment (grade) and horizontal alignment (curve radius) of the road geometry.

To find the location of Cracks/Ruts we require Coordinates or Geographic information.

5.2. Devices Required-

- HDTV Cameras for capturing images and videography.
- Dual scanning lasers to measure depth.
- Laser SDP for real-time roughness index calculation and road texture data.
- Gyroscope to calculate horizontal and vertical alignment.
- GPS system for location coordinates.
- Axle and body accelerometers for vertical acceleration.

6. Measurement Principles

Devices are mounted on a van and this system measures and records various condition parameters of the road. System will be mounted on the roof and backside, so that operator gets enough space for observation during data collection. RRAS system will require following measurements to analyze the road condition precisely-

1) Roughness Measurement
2) Rut/Crack Depth Measurement
3) Orientation Measurement
4) Road Performance Measurement

According to the measurements done, road condition is analyzed. Various measurements require various subsystems to perform those measurements. Following is the small information regarding how various measurements are going to be done-

6.1. Roughness Measurement-

In this part, acceleration of the vehicle is measured caused by the roughness of the roadway. These are the roughness indices which cause surface ride quality-

- Root Mean Square Vertical Acceleration(RMSVA)
- Mean Absolute Slope(MAS)
- Texture

6.2. Rut/Crack Depth Measurement-

In this part, depth of cracks and ruts is measured by the data collected from laser sensors.

6.3. Orientation Measurement-

This task is performed by IMU (Inertial Measurement Unit) which consists of gyroscopes that compute HEADING, PITCH, and ROLL. Results obtained are used to determine direction of travel, radius of curvature and super elevation of a roadway. In conjunction with rut depth measuring system cross fall of the roadway is also obtained.

6.4. Road Performance Measurement-

After performing the described measurements and applying some sort of polynomial function which fits traverse profile Road Performance is measured in the form of some Index.

7. Roughness Measurement Subsystem

Background-

This subsystem basically consists of two parts: Hardware and Software. Hardware consists of axle and body accelerometers, amplifiers, low pass filter and analog to digital converter while the Software part consists reported roughness statistics like Root Mean Square Vertical Acceleration(RMSVA), Texture and Mean Absolute Slope(MAS) which are further processed. Roughness statistics used are described further.

7.1. Root Mean Square Vertical Acceleration(RMSVA)-

Mathematical definition of RMSVA is –

$$RMSVA = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left[a(i)\right]^2}$$

where N is the number of samples in
a section and a(i) is the ith discrete value of filtered
acceleration where any DC bias is removed.

7.2. ***Mean Absolute Slope(MAS)-***

This is cumulative value of the absolute vertical axle divided by the traveled distance. Mathematical definition of MAS is –

$$MAS = \frac{1}{2N}\left(\frac{T}{L}\right)^2 (\Delta X)\sum_{i=1}^{N}\left|Z(i)\right|$$

Where –

- T is time elapsed in seconds
- L is section length in miles
- ΔX is sample interval of acceleration values
- Z(i) = Z(i-1) + a(i) + a(i-1)
- a(i) is the ith discrete value of filtered acceleration where any DC bias is removed

7.3. ***Texture-***

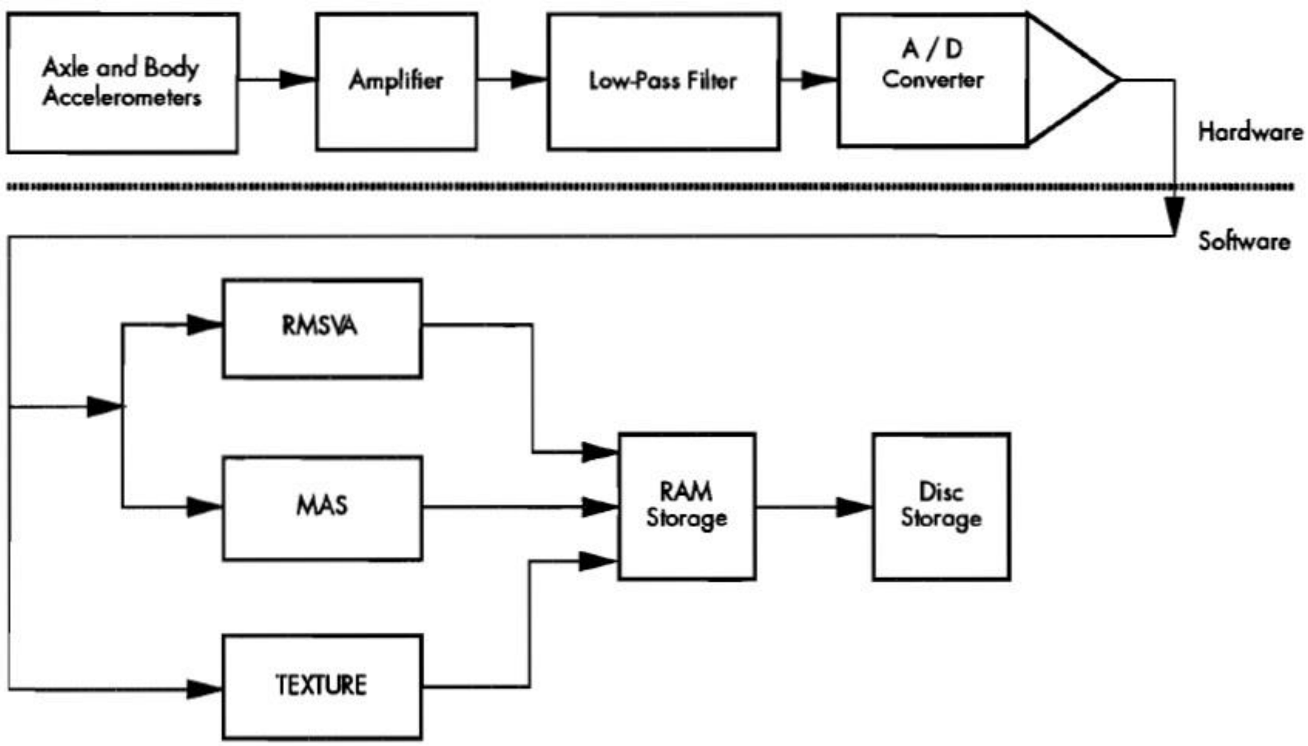
Images recorded through High Definition Cameras are further processed and texture is matched with the sample texture stored in the database and in this way texture of the roadway is analyzed and road type is determined.

7.4. ***Serviceability Index (SI)-***

Serviceability Index is determined by the equation –

SI = 5.6797 – 0.00134 RMSVA – 0.7553 MAS Taken from reference

Where RMSVA is root mean square vertical acceleration and MAS in mean absolute slope. In this way, serviceability index in linear function of RMSVA and MAS.

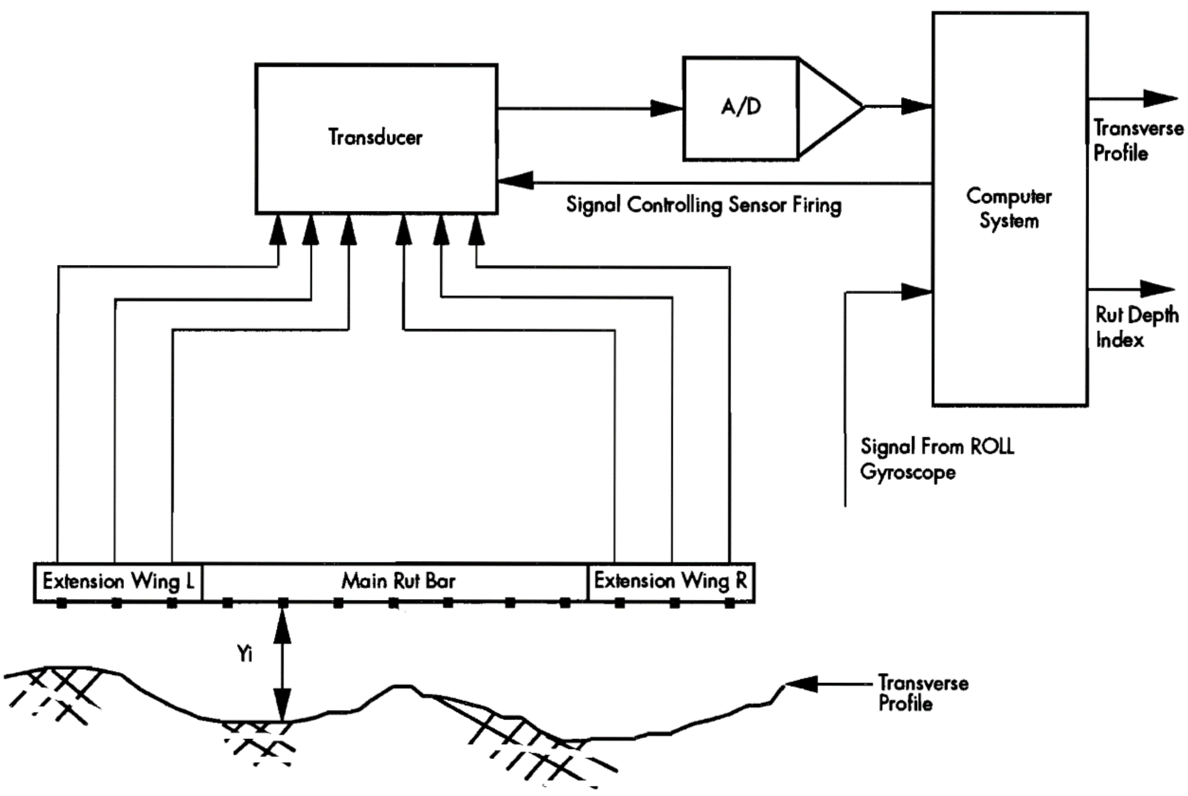


Taken from reference

Block Diagram of Roughness Measurement Subsystem

8. Rut/Crack Depth Measurement Subsystem

Laser sensors used measure the distance between the sensor and roadway surface below the sensor. Measured signal goes through transducer and Analog to Digital Converter which converts the Analog data into Digital for computer processing. Two set of wings are used for different lane width one is for large lane widths and other one is for relatively small lane widths. Chosen distance between two adjacent sensors is 1 foot, thus the interval of transverse profile is 1 foot. This data is used to calculate rut depth index and generate a transverse profile.



Taken from Reference

Rut Depth Measurement Subsystem Block Diagram

9. Orientation Measurement Subsystem

Gyroscope data passes through transducer and further Analog to Digital Converter which is further processed by Computer System. Gyroscope-I measures HEADING and Gyroscope-II measures PITCH and ROLL. Measurement of HEADING is used to determine road direction (0° to 360°) and measurement of ROLL and PITCH is used to determine the slope.

9.1. Heading-

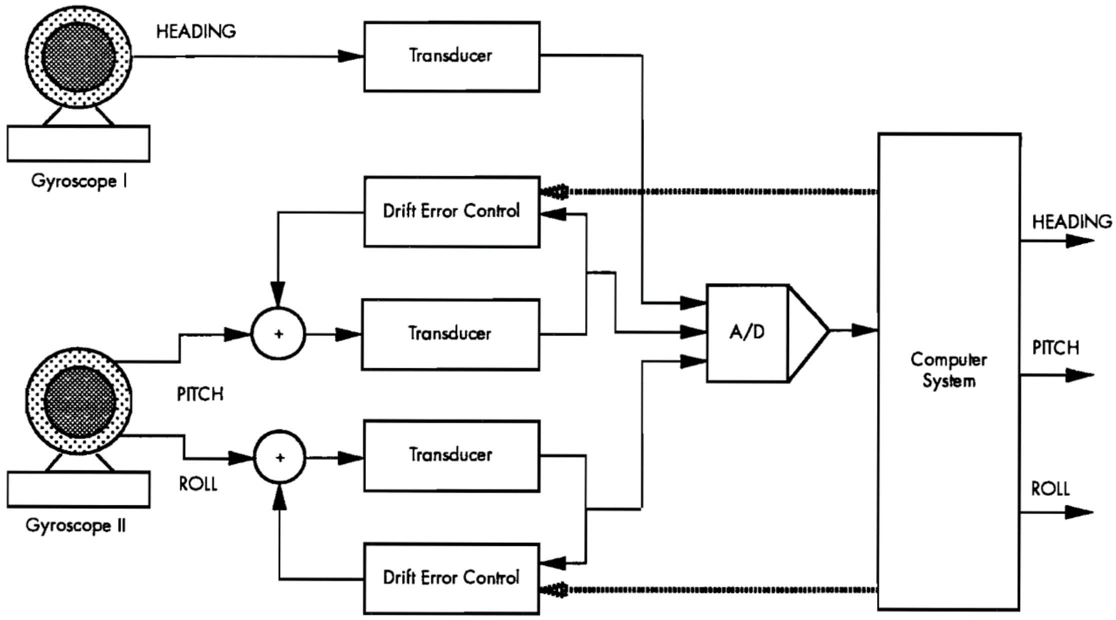
It is used to determine the direction in which our analyzing vehicle is moving. It can be further processed and analyzed to get the estimated radius of curvature and relative direction of a roadway which the vehicle has traveled.

9.2. Pitch-

Pitch is used to determine grade or slope of the road in percent rise. Rise is the distance that the road falls or rises over a separate distance. Example: If a road rises 5 meters in 100 meters then the slope is 5% or PITCH = 5

9.3. Roll-

This determines the road super elevation as a percentage. It is used in conjunction with the laser sensors to determine cross fall. Roll gyroscope is on the same plane as rut bar so that effect of the vehicle roll through corners is removed.



Orientation Measurement Subsystem Block Diagram

10. <u>References</u>

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