Road Profile Level Detector for Profile Leveling and Drafting

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***Abstract*—The project road profile level detector for profile leveling and drafting is done for determining the 3D detailed view of the road terrain. We have designed a device that is used for leveling of road or any other terrain. We have attached ultrasonic sensor in the frame attached to the vehicle for resonance free environment. It shows the output in a detailed 3D profile of road or terrain as well as stores all the data in the system. This device is attached to the vehicle to carry out work in an efficient way at both day and night time. This device will be a key for future development in civil engineering field and introduce automation in surveying.**

Keywords—Surveying, Leveling, Profile level detector

I. INTRODUCTION

The project road profile level detector for profile leveling and drafting is done for determining the 3D detailed view of the road terrain. Although there was many equipment for determining the level of the road they are time consuming, requires high labor requirement and skilled labor. Hence for the easy leveling of large terrain we have made a device that provides a pictorial representation of a larger profile in a 3D view. The device may be attached to the vehicle for easy leveling.

The quantitative evaluation of a road surface is important in order to maintain the road effectively. The condition of a pavement influences not only the safety of drivers, but also the comfort level of both drivers and the surrounding environment. Without appropriate maintenance, a damaged pavement can further deteriorate; large cracks and potholes can even cause accidents as well as poor drive comfort and loud noise emissions. Practical road condition assessments widely employed by road owners can be categorized into two groups: those employing visual inspection, and those using precise measurement techniques by employing lasers and other sensors. Visual inspection can be performed without using expensive instruments though the quality of evaluation relies on the skill of the inspectors; the evaluation is subjective. A precise profile measurement typically employs laser and inertia sensors to estimate the profile at regular intervals [1][2]. The laser-based method provides profile estimation with a high accuracy and resolution. However, especially with ordinary road networks, their frequent evaluation through the use of the laser-based method is impractical because of its high cost. A response-based road roughness condition evaluation that is low cost and also provides an objective assessment in terms of some indices has been widely studied. González et al. [3] propose a power spectrum density (PSD) method for the estimation of the roughness of a road surface, based on the transfer function from the road profile to the vertical acceleration of the vehicle body. The performance is validated by several simulations using different road roughness values generated by ISO classes [4]. DRIMS [5][6][7] evaluates the International Roughness Index (IRI) [8], a ride comfort index defined as the accumulated relative displacement of the suspension spring of the Golden-Car, using an accelerometer installed above a vehicle axle. A measurement vehicle is modelled as a Quarter-Car (QC); the ratio of the Golden-Car response power spectrum to the QC response power spectrum is estimated in advance and multiplied by the measured responses.

The responses of the Golden-Car on the measurement target road are thus calculated. IRI is then estimated based on a correlation analysis. To account for both pitching and bouncing motions, DRIMS has been further improved by using a half-car (HC) model taking into account the measurements of both vertical acceleration and angular velocity of the vehicle body using a smartphone [9][10][11]. The IRI estimation was performed in the frequency domain utilizing the ratio of the Golden-Car response power spectrum to the HC model response power spectrum. Other smartphone implementations to estimate IRI have also been reported [12]. These response-based methods evaluate the road condition in terms of specific indices or classification. However, accurate road profile estimation remains challenging. There are some response-based techniques to estimate road profiles. Road roughness reconstructions based on artificial neural networks have been developed [13][14].

A parametric adaptive observer based on the YK parameterization (Q-parameterization) has been used to estimate the road profile [15][16]. Sliding mode observers were also employed for road profile estimation [17]. Combinatorial optimization approaches have been applied to road profile estimation problems [18]. There have been similar applications to railway profile estimation as well [19][20]. A stochastic method was found to have improved its computational efficiency by using Kalman filters [21][22]; the performance of this estimation technique was validated by using sensor-equipped vehicles with known dynamic properties. These methods can estimate road profiles with various levels of accuracy, complexity, and computational cost. However, to date, those methods with experimental validations require the dynamic properties of test vehicles to be known in advance from the vehicle manufacturer, or via laboratory tests and/or suspension motions to be directly measured, which are impractical with smartphone instrumentation.

These limitations make these methods impractical to implement on a large scale using a variety of vehicles for frequent and quantitative road condition assessment. Road profile estimation techniques measuring only the vehicle body motion, on the other hand, typically employ simplified models (e.g., single DOF model and Quarter-Car model) and their calibrations [12][23]; the accurate profile estimation capabilities including the corrections in the drive speed dependency and sensor location dependency are thus limited. As far as the authors are aware, there have been no accurate profile estimation methods capable of correcting the differences due to vehicle characteristics, drive speeds, and sensor installation locations purely by using of a smartphone or another single sensor installed on the body of a vehicle with unknown dynamic characteristics. To address these issues, a response-based road profile estimation using multiple outputs measured by a smartphone installed on ordinary vehicles is proposed in this study. The algorithm consists of two steps. Initially, the measurement vehicle is modelled as a HC; its parameters are identified by a genetic algorithm (GA) when the vehicle drives over a hump of a known size. While the concept of calibrating vehicles using humps has been utilized in numerical simulations in the past for the HC roll model [18] and implemented in practice using QC [7], a practical implementation has to address issues such as the synchronization between the hump input and the vehicle response. In particular for the pitch HC model, the drive speed uncertainties and a large number of unknown parameters make the calibration difficult.

These issues are addressed by using a GA with the response power spectrum as the objective function, which is robust against the synchronization error. Next, with the calibrated vehicle model, an augmented Kalman filter is designed to estimate the road profile. The road profile is included in the form of augmented state variables and estimated through Kalman filtering. RTS smoothing, a computationally efficient smoothing algorithm, is employed to improve the estimation accuracy. Note that none of the QC, HC, or full car models can exactly reproduce the dynamic behavior of real vehicles. Stochastic methods capable of dealing with modeling errors, such as the Kalman filter, are thus advantageous.

As far as the authors are aware, this is the first study to propose an augmented Kalman filter satisfying the observability condition of the pitch HC model using no more than a smartphone on the vehicle body, together with RTS smoothing. While considering a large-scale 3 implementation of the proposed algorithm on a variety of commercial vehicles equipped with smartphones [11][24], the capability to calibrate a variety of vehicles in a simple way and the ability to estimate profiles at a computationally inexpensive cost are both important.

II. EASE OF USE

Need of the project

It reduces the usage of high cost equipments since costly equipments need to be handled properly and it also consume time, but our main objective is to reduce the time and cost for carrying out the leveling of the large road or any terrain profile.

Scope of the project

- To know the level of the site.
- To analyze the ground surface.
- To provide 3D detailed graph in Excel.

Advantage of the project

- To reduce the time consumption and high labor requirement.
- It does not require high skilled labor and equipment's.
- It also helps to complete the leveling of large terrain in a short time.

III. LEVELING

A. Leveling

Leveling is a branch of surveying in civil engineering to measure levels of different points with respect to a fixed point such as elevation of a building, height of one point from ground etc.

B. Types of leveling instruments

1. Direct leveling
2. Trigonometric leveling
3. Barometric leveling
4. Stadia leveling

1) Direct leveling

It is the most commonly used method of leveling. In this method, measurements are observed directly from leveling instrument. Based on the observation points and instrument positions direct leveling is divided into different types as follows:

- Simple leveling
- Differential leveling
- Fly leveling
- Profile leveling
- Precise leveling
- Reciprocal leveling

a) Simple leveling

It is a simple and basic form of leveling in which the leveling instrument is placed between the points which elevation is to be finding. Leveling rods are placed at that points and sighted them through leveling instrument. It is performed only when the points are nearer to each other without any obstacles.

b) Differential leveling

Differential leveling is performed when the distance between two points is more. In this process, number of inter stations are located and instrument is shifted to each station and observed the elevation of inter station points. Finally difference between original two points is determined.

c) Fly leveling

Fly leveling is conducted when the benchmark is very far from the work station. In such case, a temporary bench mark is located at the work station which is located based on the original benchmark. Even it is not highly precise it is used for determining approximate level.

d) Profile leveling

Profile leveling is generally adopted to find elevation of points along a line such as for road, rails or rivers etc. In this case, readings of intermediate stations are taken and reduced level of each station is found. From this cross section of the alignment is drawn.

e) Precise leveling

Precise leveling is similar to differential leveling but in this case higher precise is wanted. To achieve high precise, serious observation procedure is performed. The accuracy of 1 mm per 1 km is achieved.

f) Reciprocal leveling

When it is not possible to locate the leveling instrument in between the inter visible points, reciprocal leveling is performed. This case appears in case of ponds or rivers etc. in case of reciprocal leveling, instrument is set nearer to 1st station and sighted towards 2nd station.

2) Trignometric leveling

The process of leveling in which the elevation of point or the difference between points is measured from the observed horizontal distances and vertical angles in the field is called trigonometric leveling.

In this method, trigonometric relations are used to find the elevation of a point from angle and horizontal distance so; it is called as trigonometric leveling. It is also called as indirect leveling.

3) Barometric leveling

Barometer is an instrument used to measure atmosphere at any altitude. So, in this method of leveling, atmospheric pressure at two different points is observed, based on which the vertical difference between two points is determined. It is a rough estimation and used rarely.

4) Stadia leveling

It is a modified form of trigonometric leveling in which Tacheometer principle is used to determine the elevation of point. In this case the line of sight is inclined from the horizontal. It is more accurate and suitable for surveying in hilly terrains.

IV. WORKING PROCEDURE

In our project for analyzing road profile level detector for profile leveling and drafting is based on a device that uses ultrasonic waves for measuring the distance from the ground surface. The ultrasonic sensors are fitted to the frame of the cycle in which the ultrasonic sensors are controlled with the Arduino UNO. Then with the help of Microsoft excel with the built in data streamer the data of the leveling is fed continuously and stored. The data that are fed in the excel tables are displayed in the form of graph continuously. The leveling of the data for large surface terrain can be imputed in every one second. The output will be displayed in the form of 3D graph in the total terrain. It is quite useful for input in BIM as these data obtained from the leveling is useful for future references. In this we have also started our project from the initial of material collection to the completion and result of the project.

Line diagram

Processing of the device

The processing of the device is done in the following steps as the ultrasonic sensors that are connected to the Arduino UNO and the sensor were fitted to the frame. These sensors send ultrasonic waves which get reflected after bouncing back from the ground is received by the receiver in the ultrasonic sensor. The collected data are fed into the excel with the help of built in data streamer. These collected data are output in the form of a detailed graph using the excel.

V. CONCLUSION

Thus in our project of road profile level detector for profile leveling and drafting we have taken leveling using our device inside the college campus and also by cross checking using the leveling using the total station we conclude that the output is well and in a detailed format of the 3D graph. It also can store a more number of data for our project and also it provides time reading in which it is taken out to be in an well organized form of the project.

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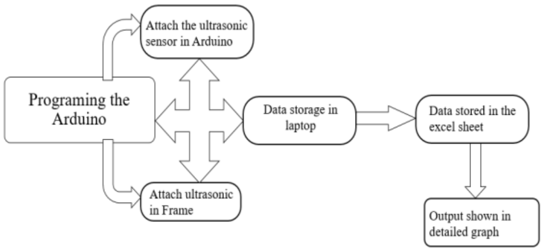

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