Using commercial drive recorders for paved road maintenance monitoring in the Federated States of Micronesia

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1. Introduction

The Federated States of Micronesia (FSM) is a tiny Pacific island nation located in the northern Oceania region. It consists of over 600 small islands and has a population of about 105,000 people. The capital, Palikir, is located on one of the four states of the FSM called Pohnpei.

The biggest challenge that the FSM's road infrastructure faces is the lack of road maintenance management plans set in place. In fact, the government of the FSM has no such plan in order to prevent high life cycle costs of road infrastructure. The FSM also has no apparent drainage systems to combat its annual rainfall of 4.8 meters (Landers, 2004). The road network in the FSM is considered unique in that it is not based on a grid as most of its primary roads are windy and differ vastly in elevation as hills and mountains are prevalent in the nation. These characteristics have been observed to result in rapid road deterioration.

The international standard for evaluating road conditions is to use the International Roughness Index (IRI). Smartphone applications that measure IRI have already been used in practice for the past few years. These apps are an easy tool in recording road surface conditions which is beneficial for road maintenance management. However, a number of these applications are not able to read the road's roughness if the vehicle the smartphone is placed in is very slow. Situations such as road obstructions, intersections, traffic, and paved road damages all contribute to the deceleration of the vehicle. Since the FSM is filled with paved road deterioration, the addition of the drive recorder would be able to visually evaluate the road surface of areas in which IRI is not measured. In view of the fact that drive recorders do not measure IRI, visualization and location of the road damage would be collected and stored in a deterioration database. The first step in establishing an effective paved road maintenance plan is to gather the existing road damage data. In this paper, the study of using commercial drive recorders as a monitoring system for paved road maintenance in the Federated States of Micronesia will be demonstrated and evaluated.

2. Methodology and setup

In this experiment, a Comtec HDR-352GH drive recorder and the RoadLab Pro smartphone application are both operated. The RoadLab Pro application is installed on a smartphone. In this case, a Samsung S8+ smartphone is used. The device is then attached to a phone holder in the vehicle. With the push of a button, the app may be able to start and stop. The RoadLab Pro taps into the Samsung's gyroscope and GPS data in order to record IRI values, GPS coordinates, time, and vehicle acceleration and speed of each road section. In this experiment, since the phone and its holder were blocking the view of the drive recorder, the smartphone device was placed about 1 meter away from the center of the vehicle's dashboard. After the trips, collected data is then analyzed using Microsoft Excel.

The Comtec drive recorder is setup like any drive recorder is, with the device mounted on the center of the windshield and plugged into the 12V auxiliary car power outlet. This drive recorder is able to record GPS coordinates, speed, time, and acceleration. However, in order to extract this metadata, a Ruby code called Comtec-dr created by Mr. Shogo Kawaguchi of MIT is used (Kawaguchi, 2017). A csv file is created from the Ruby code and examined using Microsoft Excel.

For each road section, the Comtec and RoadLab Pro are employed simultaneously. Figure 1 shows the flowchart of the experiment collecting road damage data. First, the road section is examined for two situations regarding the IRI measurement. 1) If IRI is measured, check for road damage. If there is road damage present, collect the data and move on to the next section. Otherwise, directly move on to the next section. 2) If IRI is not measured, check the drive recorder for road damage. If there is damage, collect the data and move on to the next section. Otherwise directly move on to the next section.

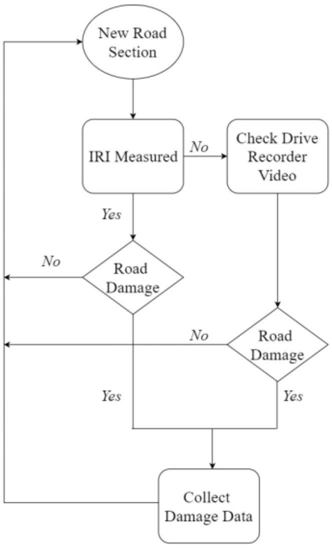

Figure 1. Methodology flow chart

3. Current results

In this study, Pohnpei state's road network is focused on. The main central network is a circle island road that encircles the island connecting the five main municipals on one main road. The total length of this road network is 77.4 km. As the state Department of Transportation and Infrastructure does not currently posses the length of the road network, this information is collected from the conducted experiment.

3.1 RoadLab Pro data

The RoadLab Pro data collected shows that there are some areas where the road's IRI is not measured. As mentioned previously, when the vehicle experiences low speeds, the app will not record IRI data. For RoadLab Pro, the minimum speed required to gather data is 15 kmph (World Bank, 2017). The average speed limit in the FSM is 40 kmph. Within two trips taken around the circle island road network, it is observed that 87.1% of the road length had its IRI measured and the remaining 12.9% did not as described in Figure 2 below.

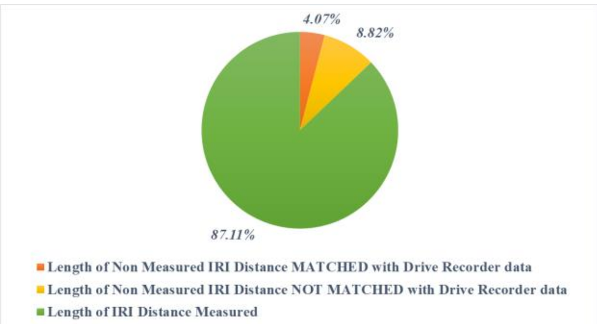

Figure 2. IRI Measurement of Road Network

3.2Drive recorder data

By monitoring the video data from the drive recorder, it is possible to locate the GPS coordinates of each type of road damage. Classification of road damage is needed in order to establish and maintain a road deterioration database. As the user will only have visual data of road conditions from the drive recorder, an easy road categorization is used. Table 1 lists and describes the road damage classification. Results show that of the total 77.4 km total length of the road, 7.1 km (9.2%) of the road network has road deterioration. Breaking down into the classification system, it is observed that potholes are the most prevalent type of road damage with 2.92% of the whole road network. Table 2 depicts the percentage of each road damage classification.

Table 1 Classification of paved road damages

Classification	Description
Potholes	bowl-shaped depression that penetrate all the way to the base course
Unpaved Surface	road pavement that has been completely stripped away down to the base course
Depression	localized pavement surface areas with slightly lower elevation than the surrounding pavement
Road Construction	government-based road projects that have cut sections of the paved road
Other	minor damage done to top of road surface such as cracks, scaling, and pothole fills

Table 2 Road damage breakdown of total road

Classification	Road Length of Damage (km)	Damage to Total Length Ratio (%)
Potholes	2.26	2.92
Unpaved Surface	0.61	0.79
Depression	1.96	2.53
Road Const.	0.64	0.84
Other	1.67	2.16

4. Discussion on simultaneous use

Although both the smartphone application and the drive recorder gather similar types of data, they differ in the way they are collected. For instance, the drive recorder collects acceleration information for every millisecond of the drive. However, the smartphone only collects acceleration data when the smartphone assumes the driver has hit a bump. Thus, acceleration data is not constantly collected. In addition, the speed and location are collected every millisecond for the drive recorder while the RoadLab Pro records this information every 1-5 seconds.

As mentioned previously, 12.9% of the road surface did not have its IRI measured. To visually evaluate road areas where the IRI is not measured, the drive recorder is employed. By noting the time and location of these areas in the RoadLab Pro and cross-referencing the drive recorder data, it is possible to see if there is damage observed in that specific section. From the non-measured IRI area, 31.6% of the distance match with the drive recorder damage data. The remaining areas are observed to have smooth road surfaces and have no correlation to the observed damage from the Comtec video.

The QGIS software is used to locate and visualize the non-measured IRI areas from the smartphone as well as the road deterioration data from the drive recorder.

5. Conclusion and future studies

As the FSM faces many road infrastructural challenges, an effective paved road maintenance management plans needs to be implemented. To start this plan, road deterioration data should be collected by simultaneously using an IRI-reading smartphone application as well as a drive recorder. For future studies, with the gathered information from both the smartphone application and drive recorder, a detailed road section breakdown could be created. In these proposed breakdowns, road sections would have an averaged IRI value assigned from the data as well as the types of road damages in the sections thus helping solve the FSM’s road problems.

6. References

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