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Case Study: Analysis and Study of Different Approaches for Road Network Maintenance

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Abstract: ***The protection and convenience of smooth traffic by the road network are governed to a large extent by the superiority of maintenance. By early identification of problem, the rapid deterioration of the roadways can be prevented. The primary intention of maintenance is to allow the movement of traffic at a desired speed, safety and not as much of cost. Road network can be preserved and prolonged if sufficient maintenance measures are undertaken at proper time. Potholes, cracks, patches etc., are some types of road surface distresses mostly used to perform manually. In the current field practices, road distress data assessment is reported to be done through distress data collection and processing of the collected raw data. This process is a labor-intensive and time consuming process and can also slows down the road maintenance management. By considering necessity for automation at present, distress data collection is increasingly being shifted towards atomization. In this paper, we analyzed, different solution which has used concept of neural network, artificial intelligence, fuzzy logic, computer vision, data-driven methods, for automation of the process. Sensor based technique and GPS based approach for monitoring road and traffic conditions to detect road distress has been analyzed.***

Keywords: Potholes, Road Distress, Image processing, Automation

1. Introduction

An arterial thoroughfare, is a high-capacity urban road, the main convenience of an arterial road is to deliver traffic from distributer roads to highways or expressways, and between inner-city and metropolitan centers at the maximum level of service possible. Road network act as the principal network to smooth out the progress of trade, transport, social assimilation and financial development. It provides line of work, extension of markets and provides greatest advantage of economies of scale. Road network facilitates for the level transportation of both people and goods. Transportation by road has the benefit more than other resources of transport because of its door-to-door service, short distance suitability and even provides service to rural area with rapid speed and less cost. It acts as a feeder to other modes of transport and hence provides better accessibility, flexibility and reliability. Consequently, passenger and commercial transportation of goods within India have progressively been more shifted over the years towards roads counterpart by other means of transport.

Growth in Road Length in contemporary nation desires to have various sources of transport. A country with high population and huge kilometers areas of road requires a transport network which can ensure quicker and faster travel across cities which are geologically isolated. It will advance the supply chain in transporting goods across cities. Indian road network consist of national highways, state highway and rural road network.

According to national highways authority of India in 2014 Indian road network is 33 lakhs kilometers and is second largest in the world which consists of Expressway length of 200 kilometers, National highway length of 79, 243 kilometers, State highway length of 1, 31, 899 kilometers, Major district road length of 4, 67, 763 kilometers, Rural and other roads length of 26, 50, 000 kilometers.

With the raise in world's inhabitants, there has been rising load on the roads. Roads have been busy with the vehicular traffic. Current Population of India in 2014 is estimated to be 1.27 billion. It has become increasingly difficult to manage such heavy traffic. One of the growing troubles the roads are facing is intensified thoroughfare. Because of many reasons like rains, oil spills, road accidents or inevitable aging makes the road difficult to drive upon. Also because of the bad road conditions driver gets frustrated and even unexpected hurdles on road may cause more accident. This leads to the wastage of valuable fuel and causes increase in vehicle petroleum expenditure.

The transportation sector in India plays as vital part in the country's profitable growth and expansion which also consumes a large amount of the total commercial energy of the country. It is the second main energy consuming sector after industry in India. It also consumes the prime share of the nation's petroleum products. According to Energy Statistics 2013 the sector's rapid growth and the near exponential increase in vehicle ownership in India, has become one of the fastest growing energy demand sectors in the country.

According to national highways authority of India in 2014 it has found about 65% of goods and 80% fare traffic is carried by the roads. National Highways constitute only about 1.7% of the road network but carry about 40% of the total road traffic. Quantity of vehicles has been increasing at an average rapidity of 10.16% per year over the last consecutive six years.

2. Motivation

Major problem to efficient communication and transportation are potholes, cracks and patches of the road surface. The most common harms are associated with the environmental conditions i.e. sun, weather, and those regarding to the surroundings such as partial shade on the roadway. When road weathers potholes occurs on the

surface, can cause damage to vehicle. Damages like puncture and wheel damage, impact of fender and bumper cracks cause damages to the lower part of a vehicle, potholes causes rapid braking and steering wheel function. This all affects to the lifespan of vehicle. Terrible road conditions increases energy consumption of the automobile and also leads to wastage of precious fuel. As per MORTH Indian Road Congress 2004 an annual loss of approximately over Rs.6000 chores ($1.33 billion) was incurred through increased vehicular operating costs due to poor road quality. All these reasons urge that hurdles on the road to be accessed by collecting the information of such bad road conditions and provides quality solution to overcome from such situations to have smoother, faster road transport.

Road condition evaluation is necessary when developing thoroughfare network maintenance programs. Pavement distress detection techniques for cracks, potholes, patches traditionally used to perform manually which is labor-intensive and time-consuming.

3. Literature Review

Manual survey processes are time consuming so sophisticated solution is the current demand to resolve maintenance issue for Indian Road network. Several efforts have been made from expertise to develop tools and machinery which can mechanically detect and distinguish potholes. This will step up to analyze effectiveness and pavement worthiness through earlier exploration and instant action. So far evaluation of road distress grouped under three major categories manual, sensor and image based system .Earlier work has been carried out by using the concept of Neural Network, Fuzzy logic Approach, Genetic Algorithm, Image board technique, Sensor and GPS based techniques.

4. Approaches

Monitoring road condition is a challenging task. Summary of Different approaches used for roadways maintenance is as follows:

I. Approach based on Data Driven Logic:

Existing method for pothole detection is based on the approach of pothole classification by collecting video data [1]. Work has been carried out by collecting video data using an optical device mounted on a vehicle. Applied decision method on 2D Database to detect potholes from the collected video data using signals of input frames to find region of interest. Here cracks are not considered as a form of distress. Another vision based approach focuses to detect distress on the road surface by selecting images from camera appropriate for inspecting on lighting and climate conditions. Proposed work has carried out by a technique of weakly supervised learning algorithm and also by an over-segmentation algorithm to train classifier and detect the presence of pavement distress that identifies coherent image regions by considering of colors and texture parameter. A robust method [5]for potholes cracks and patches detection has been proposed and quantified automatically by DFS and CDDMC algorithm supported by heuristically derived decision logic.

II. Approach based on Image Segmentation Technique

A multi-scale extraction and a Markovian segmentation approach [9] has been proposed for evaluating the task in the field of noninvasive sensing techniques for addressing the problem of crack detection. Evaluation and comparison protocol has been intended for Gamm and Morph method. Morph method obtained more positive results. Method has been validated, analyzed, and compared to a detection approach based on morphological tools. Histogram shape-based thresholding technique [10] has worked on image segmentation into defect and non-defect regions. On the concept of defect region properties, the potential pothole shape is identified using morphological thinning and elliptic regression. Approach has been implemented in a MATLAB, with trained and tested 120 pavement images and obtained an accuracy, recall of 86% and precision of 82% **.** Improved C-V segmentation method [11] proposed, it substitutes the local region with a narrow band of the active contour line region in C-V model. Using iteration equation, the original image is replaced with the gradient image to practice pavement distress images. The implementation results show that the inhomogeneous objects could be segmented successfully and achieve high-quality outcome. Similar work has proposed by approach based on segment extending for complex pavement images for automatic crack detection [16]. By analyzing the relationship between connected domains, interrelated segments are connected to form a crack and identified crack direction using cracking recognition technique. Real roadway images are used to validate the performance of this technique. An automatic pavement crack detection system has been developed using Visual Studio C++ 6.0.[13]Work has been carried out by pre-processing of road gray-scale image and variety of image smoothing technique. Algorithm of image threshold segmentation applied to do a pre-segmentation of “disease” of crack category, and also used crack refinement technique applied to calculate the area and length of “disease” accurately.

III. Approach based on Fuzzy Logic Technique

A fuzzy inference system has proposed [6] by comparing various pavement distress data against threshold values. A fuzzy inference system is a rule based system of fuzzy if-then rules, which evaluated a database on the membership functions. A decision-making unit performs the inference operations. A defuzzification interface transforms the crisp inputs with degrees of match and linguistic values and the fuzzy outcome of the inference into a crisp output with good accuracy of classification. Output observed 56% correlation between fuzified based PCI and conventional PCI. Fuzzy sets theory resembles human decision making, basically used to mathematically represent uncertainty and deals with the imprecision in numerous applications. Another fuzzy logic inference system based model constructed based on expertise opinion to obtain fuzzy rules[7]. The technique has been used for planning of maintenance treatment selection for the black topped pavement surface. Fuzzy Multi Criteria Decision Making system is proposed to measure the functional condition of

the pavement. Pavement problems with respect to their level and severity have been collected over a number of stretches and undergone inspection by skilled mind-set [18]. Ranking of stretches has arrived on the calculation of Priority Index (PI).Fuzzy mathematics technique [19] used as a tool to incorporate subjective analysis and uncertainty in pavement condition rating and maintenance-needs assessment. Computer programs have been developed for PC operation that allows for straightforward revisions of the assessment basis, and has a unit for training of new staff.

IV. Approach based on Neural Network

A fully incorporated system for the automatic detection and characterization of cracks in elastic road pavement surfaces is proposed [4] .Crack detection is done from samples of the available image database which is mechanically selected and trained by unsupervised training algorithm. This system classifies non overlapping image blocks as either containing crack pixels or not and characterize the detected cracks connect components. Experiment has been performed on Portuguese roads images captured during a visual road pavement surface survey provides promising quantitative results. Neural Networks based approach [12] proposed for identification and classification of cracks into separate types. The system replace human labor and helps for managing task for road administrators. A backpropogation based artificial neural network pavement crack recognition method in the area of image processing has also been presented [15], where self-studying feature of neural network is used to for the cracking identification. Cracking trend calculated by converting cracking recognition to the cracking probability judgment for every sub-block image, and a technique for revising the neural network output is proposed to gain accuracy of identification.

V. Approach based on Sensor Based Model

For monitoring road and traffic conditions [8] applied non-intrusive smart phones method using sensors. This method used accelerometer, GPS and magnetometer sensor readings for traffic and road conditions detection, identification and braking events. Out of 37 breaking events system identified 29 correctly with false +ve 2.7% and false -ve 21.6%. A Nericell system [14] has proposed and focused specifically on the sensing component, which uses the accelerometer, microphone, GSM radio, and/or GPS sensors in the phones to detect potholes, bumps, braking, and honking. Nericell addresses some challenges including virtually reorienting the accelerometer on a phone that is at an arbitrary orientation, and performing honk detection and localization in an energy efficient manner.

VI. Gabor Function

Image analysis using the Gabor function is proposed [3], gabor filter is proven to be a highly potential technique for multidirectional crack detection. This method for crack detection is directly related to the mammalian visual perception and has reported of up to 95% precision in crack detection. The technique has limitation it only works for crack detection.

5. Conclusion & Future Work

To critically perform correct identification and classification of potholes, patches, and cracks as well as to provide qualitative solution for maintenance.

The challenges in this context are:

As in the developed countries mostly reported research has focused on the automated detection and classification of cracks. Cracks are the earliest forms of the distress. Developed countries will have more focus on identifying crack before it becomes critical. In Indian road distress issues are mostly available at the pothole level rather than the crack level.

One of the important concepts identified in existing work is, in world developed countries problem of color intensities of potholes, cracks and patches are darker than the background color intensities in road surface image. While in India road distress, it is found that cracks and potholes filled with dust, makes the distress brighter than the background of road surface image.

Considering all the challenge current focus requires on:

- Better and sophisticated data acquisition system.
- Advanced, robust and highly effective evaluation in the area of image processing system requires standardize and automate process for detecting and repairing potholes. Further there is scope of development of algorithm for automated classification of cracking types and measurement for severity levels for potholes and cracks by considering visual properties of data.
- Need of using Machine learning technique to automatically train and classify data for detection of distress effectively with greater accuracy.
- Expanding the scope of Indian road network dataset to image mining we can provide the complete automated process which achieves good accuracy of the image evaluation.

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