Online monitoring system for road construction activities and projects

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Abstract: Roads are vital for working economy. New road projects are established frequently by every government. Such projects must be monitor well to get work done on time with high quality. For this purpose, we have specifically modeled an integrated online system. The web based system integrates administrative body, contractors and public community. The system provides for data-driven and feedback based monitoring. It ensures quality among projects while tracking the speed of progress. It provides visual ways to analyze progress and issues regarding road construction.

Index Terms –Roads, Monitoring, Administration, People, Web based, Integrated.

I. INTRODUCTION

Roads are the major part of nation’s asset. More importantly it is the backbone for development in urban and rural areas. The construction of roads is largely facilitated by governments. Many road projects run across all regions. Contractors play big role as they are the primary implementers. Being said the importance of road projects; it is also a reality that many road projects suffer from poor management, delays and bad quality. This derives the need to track and monitor these project activities. Both governmental authorities and contractors have handling and control over projects. However, one major missing link which is often excluded from monitoring and controlling are the people. In general, authorities, contractors and people are three major stakeholders in road constructions. So the monitoring system should be such that it integrates all these three stakeholders. As far as the monitoring is concerned, the conventional manual monitoring of construction activities tend to be tedious and inefficient. It is time consuming and often inaccurate. This is due to, lack of communication and timely actions. Also it completely ignores people in the monitoring process. The efficient modern approach is to have an online system that can collaborate between these stakeholders. An online system can also provide system specific features which can benefit the process. This paper covers the key aspects in implementing such system alongside with methods of monitoring. Apparently, data has a vital role in this system. Most of the previously done research on this topic suggests that data collection is crucial and there is a need to conduct both manual and automatic data collection to make monitoring efficient and transparent. The proposed system stated in this paper also gathers data from common individuals as they are the daily watchers of such activities. This again ensures transparency and avoids misinformation. Another concern is in presenting information. Using data analytics for data driven construction progress and NLP driven sentiment analysis for people module, the system is modeled to show information visually.

II. LITERATURE REVIEW:

Road construction monitoring systems have been researched several times in the past.

Junar A. Landicho (1), proposed a geographical project monitoring and information system for roads. In his paper, he studied the importance of proper road monitoring for maintaining roads. The purpose of the study was to design and develop a program application that could provide information about the road projects in more informative manner and can be easily accessible to public.

R. Navon & Y. Shpatnitsky (2) outlined the need of automated monitoring of road construction in their paper. The purpose of their model is to automatically collect and process monitoring data with real-time control information. It uses GPS technology for automated data collection, logging the location while working on the project. Their model was implemented and tested for 3 weeks in a project. Results were calculated and compared with manual monitoring with deviation of +5%.

Shabtai Isaac, Ronie Navon, (3) in their research about automation in monitoring found that, certain manually obtained data are still required in addition to the automatically collected data. They proposed a framework for semi-automated project monitoring and control, in which both manually and automatically collected data can be incorporated.

As per the article published in a blog of ”worldbank.org”, under the title of "Engaging community in monitoring of road projects” (4), author clearly described the effect of community participation in road projects in India. According to article, government of India in 2000 announced a massive Rural Roads Program, called Pradhan Mantri Gram Sadak Yojna (PMGSY), to provide good connectivity across villages and regions. It introduced "Citizen monitoring" gradually in the project. It includes community members from relevant geographical areas and they are involved in monitoring of road project to ensure satisfactory quality of the road. Community monitoring also gives users ownership of roads and helps the project progress as scheduled. Citizen Monitoring of PMGSY roads has been entrusted to Public Affairs Centre (PAC), Bangalore. PAC has initiated Citizen Monitoring through the State Level Partner Organizations (SLPO) on pilot basis in three states, Rajasthan, Meghalaya and Jharkhand. A total number of 70 roads had been identified for implementing the citizen monitoring in three states. This includes 30 roads in Rajasthan, 20 roads in Meghalaya and 20 in Jharkhand.
III. SYSTEM MODULES AND METHODS:

3.1 COMPONENTS

Proposed system comprises of various modules namely-
1. Administration
2. Contractors

System integrates all the above three modules. Each module will have its standalone existence. Also these modules communicate with each other and shares data.

Administration corresponds to governmental authorities which plan the project. An admin will be assigned as per the area i.e. each admin will monitor projects running in his/her area. Admin will also responsible for adding new project and assign contractor to that project. Admin has username and password. All the projects under the admin will be accessible to admin. Further, admin can view project details which have components for tracking and monitoring. Information is shown in terms of numbers and percentage. Graphs are also shown. Overall project progress and individual component progress can also be seen. Additionally admin can also generate reports for documentation purpose.

Contractor will be responsible for adding relevant information about the ongoing construction activities. Multiple entries can be entered and submitted at the same time depending upon the parallel progress of different components. Contractor can access messages, suggestions in his portal that are either system triggered automatic messages or suggestions from the admin.

In people module, an individual can access project information anonymously. A person can search project with location.

View the status of project. Take surveys and add reviews about the project.

The proposed system is best suited as a web application in which the server enables integration of above modules online. The databases are used for storage of data (primarily Mysql). Server can also take location data from devices or machines located on site in real time to testify the current working sections of a road. Additionally the weather forecasting data can serve as a delay conforming parameter as weather may have adverse effect on construction activities.

3.2 UNDERLYING METHODOLOGIES:

3.2.1 Preparation of Data:

It is important to consider different aspects of road construction before doing actual monitoring task. Roads can be classified based on type, economy, material, topography, location, rigidity and so on. Road pavement is main construction unit and can be categorized either as flexible pavement or rigid pavement.

If we take an example of rigid pavement i.e. concrete pavement. it has three layers and additionally we add excavation layer as it is the initial phase. Thus layers consist: 1) EXCAVATION 2) SUBGRADE COURSE 3) BASE COURSE 4) SURFACE COURSE

Road construction follows above sequence to lay different layers. Additionally, the number of lanes also matters as the construction proceeds with constructing individual lanes.(or two lanes at a time)

Above factors will be considered under tracking. If for example, the road is of length 2000 meters. Then,

1) All four layers will also span 2000 metres each
2) One lane contains all four layers,
   Thus total length to monitor one lane will be
   \[ 2000 \times 4 = 8000 \text{ meters (for one lane)} \]
   \[ 2000 \times 4 \times 4 = 32000 \text{ meters (for 4 lanes)} \]

Thus in general, 

\[ \text{overall_construction_length} = \text{total_length} \times \text{no_of_layers} \times \text{no_of_lanes} \]

So, by making use of above numbers the system can calculate other parameters such as overall progress, individual components progress like lanes and layers. Also it outlines the total completed portion of roads also (corresponding to layer 4-Surface course)

It is to be noted that, for most of the length of road the same pattern will be followed, however some of the portions of road (very minor portions) may slightly vary from the established pattern. For example, if there are bridges, then it has different construction pattern. In this case, considering above example of 2000 meter long road, we will have to subtract bridge length

If the bridge is of length 10 meters, then

\[ \text{new_total_length} = 2000 - 10 \]

Accordingly all calculations will proceed further.

In conjunction with manually obtained data from the contractors there should be some automatic data collection that will conform and validate the results. This data collection will mostly real time in nature. A GPS is used to show active locations on the site. The location marks can be traced to validate results and follow constructed road routes. The weather forecasting information of respective project location is added to analyze working conditions. In case of cities, traffic data can also serve as useful insights.

3.2.2 Visualization with Graphs:

Monitoring methods involve visual representation of information so that better inferences can be made. For this, system makes use of various graphs to showcase time - length relationship showing the progress over time. A typical implementation is given below:
Above graph (fig. 1) shows the progress of construction over time. Each point on graph indicates total length constructed (which includes all factors like lane, layer collectively) for that day. It shows typical workflow of construction done during a certain interval of time like in month. There is one exclusive horizontal red line (axis) which suggests the expected threshold level of regular construction to meet the required deadline of construction. It expects the points to be as near from it as possible. The above graph has three points exceeding this red line indicating higher work than expected. This red line shows average expected work that should be achieved. This is calculated by taking parameters such as Deadline date, current date, and remaining work to be completed with some algorithmic approach. Due to this, the expected level is always variable in nature. It continuously move upwards if work progress is slow and vice versa. Above example was one of the few others that implements graphs, all conforming to different aspects of monitoring. Below graph (fig. 2) shows the comparison of work completed for different stages of road construction over the time. The work may go sequentially for stages occurring one after another or it may go parallel for some portion where stages get completed at same time which may be on separate parts of the road.

![Figure 1: Construction Progress](image)

![Figure 2: Tracking & Comparison of Layers](image)

### 3.2.3 Methods in People module:

One of the key part of system is the people's module. Here, people can search and view project information and status. Accordingly they can interact with the system, and the feedback will be provided to both admin and contractors. A person can enter into system anonymously. Location wise search is made for the projects. All projects near a person is accessible to him/her.

There are two basic ways a person can interact.

1) By taking Surveys
2) By adding reviews

All the data will be saved in databases and further processing is performed by the system. While conveying feedback to admin and contractors, system will preprocess the data and extract relevant details. For example, system uses review analysis to extract topics of interest from the mass reviews given by masses. For this, system uses Latent Dirichlet Allocation (LDA) algorithm (6) along with some dedicated modules for NLP. After extracting topics with their frequency of occurrences, a graph can be shown with topics and their frequency in feedback. Subsequently higher frequency topics will be considered for monitoring and taking actions accordingly.
E.g. Certain road project may cause pollution or safety issues to public. These issues may reflect in feedback from the people and they will be mined by the system.

IV. CONCLUSION:

An integrated model for online monitoring of road construction projects is a smart approach to manage projects. It facilitates schemes such as smart city run by the Indian government. System uses various techniques such as web, data analytics, NLP to derive the results. System provides better means for administrations to control activities and take proper decisions. It also encourages community participations in such road projects and the quality assurance factors can be evaluated. It reduces delays which is the root cause of financial and quality losses.

REFERENCES


