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Cognitive Radio Based Construction Progress Monitoring in India

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Abstract:
Infrastructure is a huge umbrella that brings all other industries under its cover for the social and economic development of India. Hence the authorities of India focus more on the improvement of infrastructure and construction services through strategies such as Foreign Direct Investment (FDI) norms, Smart City Mission, etc. Construction Planning and Production (CPP) based applications helps to track the utilization of men and materials from scratch till end. The drawback in the traditional method of Site Visits (SVs) is: it does not ensure consistency with the funds, inefficient planning and hence leads to undesirable outcomes. This paper proposes the cognitive radio based construction progress monitoring technique for tracking the quantity of materials required in every process and stores the updates for further processing. The proposed method is cost efficient and hence reduces delays and uncertainty problems.

Keywords: *Construction progress monitoring, Cognitive radio, Bayesian Network, Embedded C, Uncertainty problem*

I. INTRODUCTION

Increase of investments in real estate and infrastructure projects makes the construction industry to flourish continuously in our country. KHL group [1], forecasted that the Indian construction industry will thrive to an average of 6.4% in the year 2023 and the budget allocation in infrastructure projects has increased by 20.9% by the Government of India (GOI). The Construction Planning and Production (CPP) based embedded applications helps to track the utilization of men and materials from scratch till the completion of the work or product. The tasks involved in CPP are material analyzing, day's calculation for

manufacturing, maintenance cost and quality assurance [2]. All the mentioned tasks are interdependent of each other and forms the most critical and complex issue while monitoring the progress of construction.

The introduction of digital technology [3] is making an impact in the construction progress and offers reliable solution to the users from the real time field. Construction site embedded with automated monitoring system guarantees a plethora of activities such as the latest progress details, schedule and cost which enables us to act quickly and efficiently as early as possible. Some of the benefits of such automated monitoring system are:

1. Increased rate of production
2. Precise planning and timely decision making
3. Efficient usage of men and materials

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4. Improves scheduling due to fast collection of data and its analysis
5. Easier way of identifying and preparation of daily construction reports

The advancement of automation in construction progress has reached a point of synergizing the technologies such as computer vision and robotics. However, many of the construction sectors do not employ them since it increases their price estimation to a higher level [4]. In case of SVs, the client does not aware about their ongoing construction work and hence they are dependent on the contract managers [3]. To facilitate the client, we propose the idea of cognitive radio based construction progress monitoring technique which stores the construction progress information and accumulates them with the help of sensors deployed at the sites. The accumulated data are further reported to the centralized base station and the final decision will be predicted by it. With the help of Bayesian Network (BN), the assembled data are converted to patterns which are analyzed further and offers the best forecasted update in order to maintain the data consistency.

The construction progress automation faces challenges such as interferences and penetration losses and hence high transmit power is required. Such challenges are solved on deploying Cognitive radio (CR) technique [23]. CR identifies the unused spectrum, changes its transmitting parameters according to the environmental situation and thus mitigates the problem of interference and battery consumption. It consists four features (Figure 1) such as:

- Mobility (supports the nodes to move freely from a position to another),
- Sensing (observation of the environment for parameters such as frequency, modulation, transmit power, etc),
- Decision (Once the parameters are finalized, the node will adapt the suitable parameter for such working environment)
- Sharing (Distributes its information to its peers and thereby ensuring coordination among themselves)

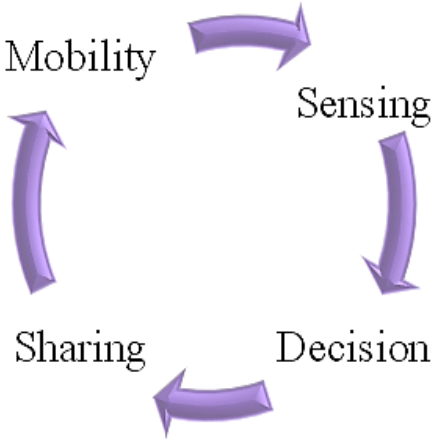

Fig. 1. Features of Cognitive Radio

Thomas Bayes [10] explores the knowledge representation and reasoning and presented them visually in the form of a tool called Bayesian Network. It represents the probabilistic or complex relationships in the form of variables. It identifies the relationships among the variables under different uncertainty scenarios, predicts the outcomes of various techniques and provides the optimal one to the user. Wide range of BN applications are found in medical field, risk management, weather forecasting, safety control, accident analysis, etc [8,9].

The Bayes' theorem narrates that the succeeding probability of the hypothesis (since the number of inputs varies) depends on the additional evidence E and the background context C [25] which is given in equation (1)

$$P(H \mid E,C) = \frac{P(H \mid C)\, P(E \mid H,C)}{P(E \mid C)} \quad (1)$$

where

$P(H \mid E,C)$ represents the succeeding probability.

$P(E \mid H)$ is the maximum certainty for the hypothesis.

$P(H)$ Represents the existing probability of the hypothesis and

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$P(E)$ forms the constant value.

The proposed methodology reduces the manual way of storing the customized requirements of materials, its quantity in every process and all the updates about the product. The proposed system involves a hardware toolkit that monitors the processes of requirements gathering, analysis of work and materials, production rate and its quality assurance. Moreover, it maintains a record of every tasks and the other construction information for further processing, thereby reducing unnecessary delays.

The following section reviews the state of the art and with some insights about the construction materials. Further, the proposed system is explained with the architecture diagram and the working of hardware toolkit. Later the paper is concluded with discussions and outcomes of the proposed system.

II. LITERATURE REVIEW

Soil is an important ingredient in the construction industry. The authors [11] studied the soil behaviour and its stabilization for construction purpose. The author [12] explains about the impact of globalization in building materials on using both imported and the local materials in Jordan country. He narrated more about the usage of imported building materials at few construction sites which will lead to economic decline in their nation.

A deep review of slate rocks, mining and the geological studied from [13] offers guidance about the natural slate during building construction. In [14], authors presented a research work about automated progress monitoring of construction firms in Middle East and the nearby countries and concludes that such monitoring progress have showed an impact in the construction project.

An economical way of observation has been narrated by [15] where the 3D

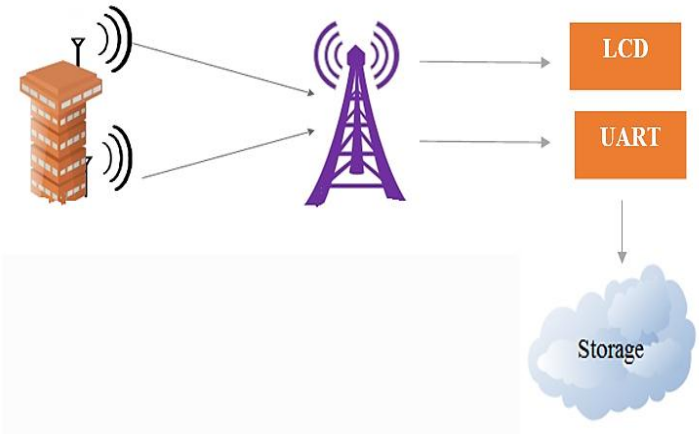

Fig. 2. Architecture of the Proposed System

scanning points are sufficient enough to construct progress model in a 4D display ad showed an improvement in project management. The authors [20] developed a Geographic Information System (GIS) where the planning, designing and scheduling of building model in a database with the attributes such as materials, dimension, persons, safety information, etc.

The author [17] introduced the concept which combines the sensing and augumented reality together where the produced image is compared with the referenced image. On comparing, percentage of the construction progress is estimated and recorded on the daily basis whereas in [16] followed the above concept, however they validated the captured image with help of image processing and predicted the period required for the concerned project.

Authors [18] collaborated the building information modelling (BIM) and unmanned aerial system (UAS) for the construction progress monitoring where the updates are analyzed using data analytics approach. In [19], authors demonstrated a evaluation method for calculating the work progress in construction fields using Earned value method (EVA). The author in [21], proposed that lean techniques, enterprise resource planning (ERP) and artificial intelligence helps to monitor the complete construction projects from the scratch till the completion of the project

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through the continuous monitoring of resources thereby increasing the profits in construction.

The author in [22], narrated about the unpredictable events occur in the construction place and suggested a pattern of understanding the pace of the workers using the wearable attached to them. During any unnatural circumstances the patterns received from various sensors predicts the possibility of occurrence in construction environment.

III. PROPOSED SYSTEM

In the proposed system, a collection of CR nodes, a base station with micro controller capabilities and a cloud storage (as a database) forms the main components. The details and information regarding the construction of a building are sensed by the deployed sensors at the various locations. Example of the information are: Number of floors established, Number of rooms constructed, Number of labours hired for the work, Amount of materials consumed to build the flat, etc. Once the inputs are gathered, the CR base station will accumulate them, follows Bayesian methodology and finds the requirements, analyse the materials, calculates the work force required, estimated production rate, and ensures quality assurance. The daily construction data will be calculated and uploaded in the cloud for future reference so that whenever required, data can be revealed. The basic diagram of the proposed system are given in Figure 2.

The functional diagram of the proposed system is given in Figure 3. Three set of operations are performed: Sensing Operation, Reporting Operation and Display Operation. In the sensing

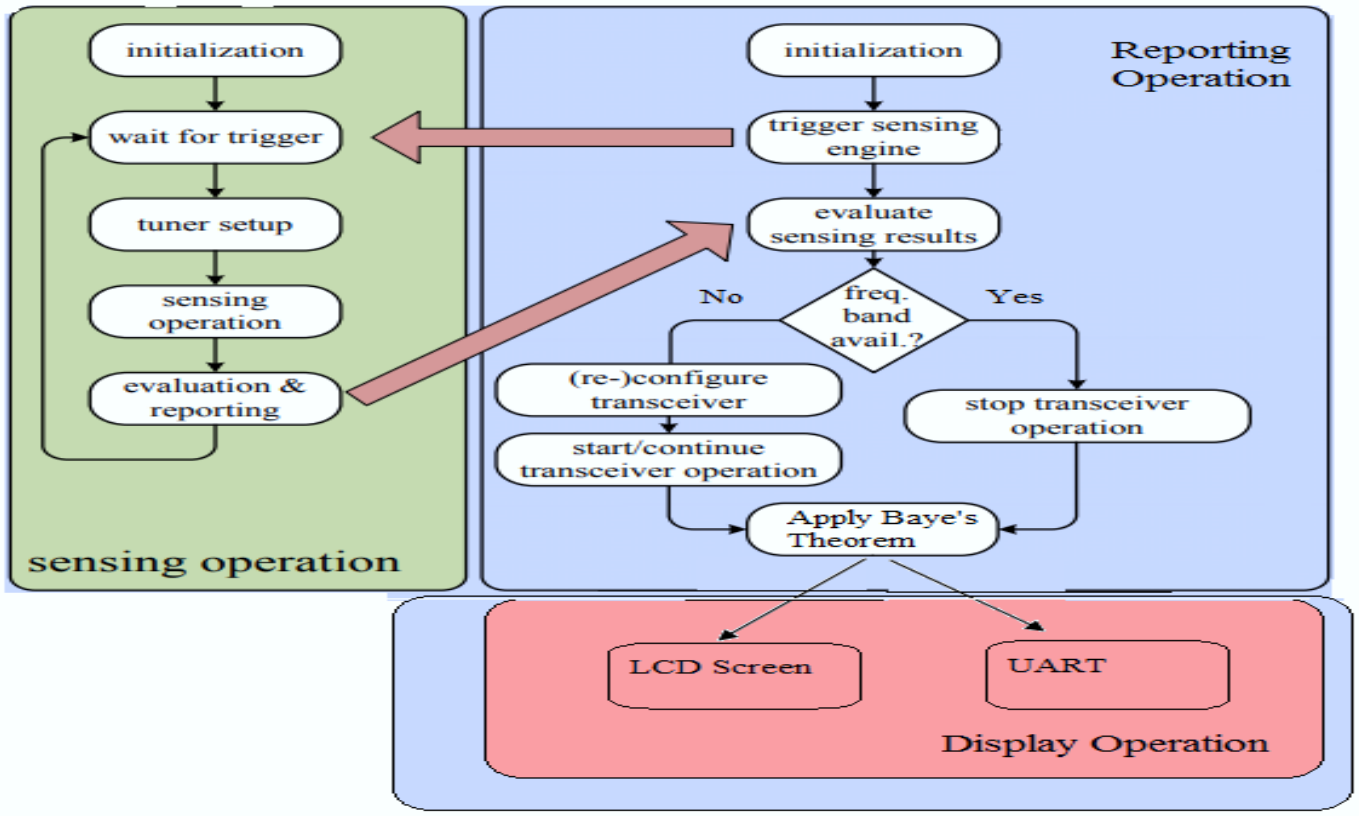

Fig.3 Block diagam of the Proposed System

operation, each node monitors the environment and tunes up as per the parameters and send the report to the base station. In the reporting stage, the base station identifies the presence of frequency, to avoid interference and also applies the Bayes theorem to find the probability of hypothesis based on the evidence. In the display operation, the final result of estimation is

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exhibited on the LCD (Liquid Crystal Display) and UART (Universal asynchronous Receiver Transmitter) for storing in the database.

IV. REQUIREMENTS AND DISCUSSIONS

The hardware requirements of the proposed system are [24]

- An Arduino Due embedded with Nordic nRF24L01 acts as the Cognitive radio node
- A reconfigurable overlay antenna to support frequency switching
- A LCD display for viewing
- An UART for sending the details to the cloud database

The language used is the Embedded C [26] as it is the most widely used language for embedded design especially for designing the architecture for hardware and application. It is inbuilt with the standard libraries and primitives for signal processing applications. The hardware kit components are written in Embedded C language since it involves a numerous signal processing methods.

The hardware kit of the base station controller used for the proposed system is shown in the Figure 4. Once the controller receives the inputs from the deployed CR sensors, it starts the calculation and provides the estimation.

For example, if the height, weight and the width of the given area is provided then the square feet of the area is calculated by the controller using Embedded C and predicts the approximate amount of materials required for construction is performed by the Bayes' theorem. Using these studies the output is received in the LCD screen which is shown in Figure 5, 6 and 7.

Fig. 5. Hardware Kit of the Proposed System

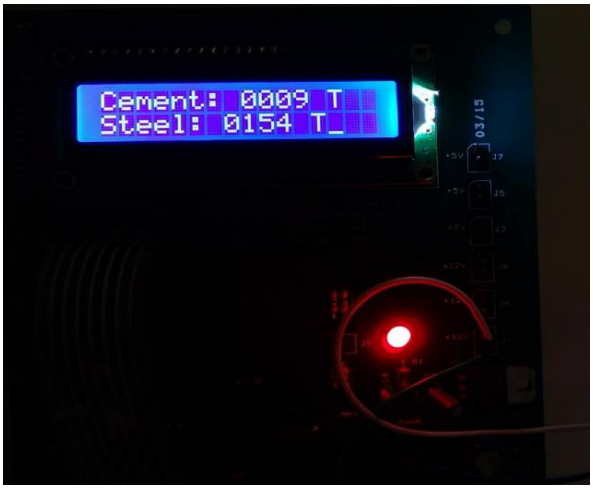

Fig. 6. Output Displayed in LCD screen

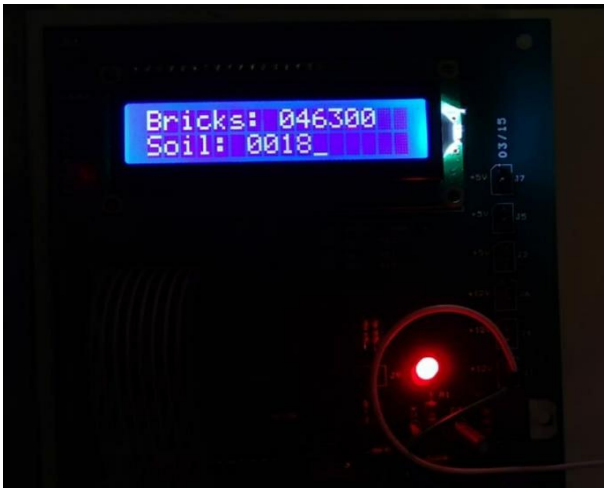

Fig. 7. Output Displayed in LCD screen

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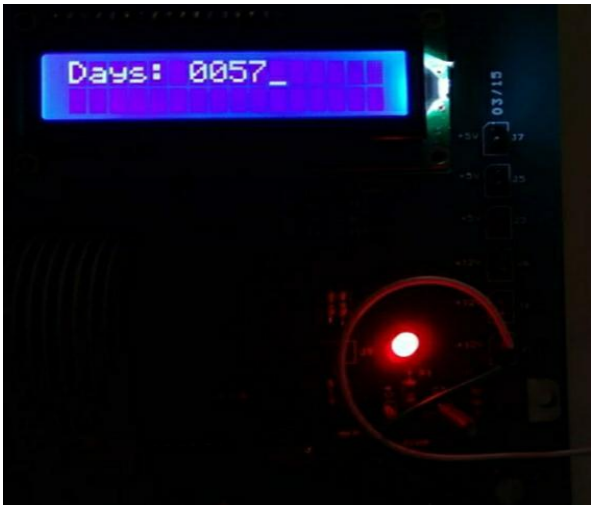

Fig. 8. Output Displayed in LCD screen

V. CONCLUSION

To solve all the existing problems in the traditional method, this idea of adaptive construction progress monitoring has been proposed. The proposed system maintains all the necessary data to construct building, assures quality in construction, cost maintenance and comfort. The advantage brought out here is, automatic data analysis using Cognitive radio based technique which senses the construction site and the consolidated progress are monitored in a better way. Hence automatic predictions is done in order to get clear vision of data. A Cloud storage is used for storing all the data entered in the system which can be used for future reference. The main advantage implied from the proposed system is to find efficient materials required and cost for the project estimated. For future enhancement, focus on biometric attendance of the workers and estimate their daily wages. All these information can be stored in cache for easy retrieval. To make this more convenient to all the users, this can be implemented as a mobile application.

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