Bridge Crack Detection & Maintenance System Using IOT& Image Processing

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ABSTRACT: Many of the bridges in cities built on the river are subject to weakening as their lifetime is expired but they are still in use. They are dangerous to bridge users. Due to high water level or pressure, heavy rains these bridges may get collapse which in turn leads to disaster. So, these bridges require continuous monitoring. So we are proposing a system which consists of a ultra-sonic sensor, led signals, servo motor and microcontroller. This system detects the water level, and cracks in the bride. If the water level, cracks on the bridge cross its threshold value then it generates the alert through LED signals and auto barrier. If it is necessary, then the admin assign the tasks to the employees for maintenance. Engineering structures are responsible for economic growth, development, and evolution of the nation. The structure includes buildings, roads, dams, and bridges which affect day to day a life of people. Along with their own weight, they are also affected by the environment. Scour is also one of the major causes of bridge failure. In 2016, a bridge collapsing incident occurred on Savitri River in Mahad district due to sudden floods in the river. Apart from this, the problem of collapsing may arise on airport boarding bridges. This project introduces bridge maintenance system which monitors the bridges through sensors and generates the alert.

KEYWORDS: Crack Detection, Image Processing, Internet of Things, Water level.

I.INTRODUCTION

Due to the complex environment of the bridge structure and its construction process, the bridge project will inevitably produce various risk factors. These risk factors are likely to cause adverse effects on bridges and even cause collapse of bridges, endanger people as lives and cause damage to property. Therefore, it is of great significance to carry out damage identification and early warning of the bridge structure and grasp the health status of the bridge operation in time. Concrete bridges exist throughout the India of various sizes and different forms.

They are integral part of highway system even though they are most neglected element of the infrastructure. From the structural point of view, maintenance plays an important role in deciding structural health of bridge. Maintenance majorly consists of inspection and detection of cracks on bridge surface. Bridge surface is always been an important concern in maintenance of bridges since surface of bridge carries all passing traffic also it is exposes to different wheatear conditions, so bridge surface needs regular inspection and maintenance.

Here we have developed a system which can inspect and detect cracks. Regardless the cause of incident, disaster leads to huge destruction in terms of economic and human lives. It has been exactly a year since the British-era bridge over the Savitri River, in Mahad , collapsed. According to officials, the collapse of the bridge, which happened at around midnight, killed 41 people. This system will provide a rapid aid to the disaster hit victims. The current system will give a real time response due to its effective means of communication with precise coordination describing the impact and alerting the commuters who are about to cross the bridge.

II.LITERATURE SURVEY

Bridges may get collapsed or tilted due to flooding or some concrete problem, natural calamities. So there is a need to design a system which will continuously monitor condition of bridges. It is useful for public safety and reduction in human losses. Such system will help in disaster management and recovery. IoT-based bridge safety monitoring system is developed using the WSN Technology. This system is composed of: Monitoring devices installed in the bridge environment, communication devices connecting the bridge monitoring devices and the cloud based server, a dynamic database that stores bridge condition data, cloud based server calculates and analyses data transmitted from the monitoring devices. This system can monitor and analyse in real time the condition of a bridge and its environment, including the water levels and other safety conditions. This paper presents a comprehensive survey of

SHM using WSNs outlining and algorithm like damage detection and localization, network design challenges and future research direction. [1]

With the development of information technology, the Internet of Things (IoT) has the characteristics of strong permeability, large use of action, and good comprehensive benefits. It promotes the development of IoT technology in the detection of structural engineering. It is conducive to the development of intelligent, refined, and networked structures. Crack is the most common threat to the safety of bridges. Historical data show that the safety accidents caused by cracks account for more than 90the total bridge disasters. After a long period of engineering practice and rigorous theoretical analysis, it was found that 0.3 mm is the maximum allowable for bridgecracks. If the width exceeds the limit, the integrity of the bridge will be destroyed, and even a collapse accident will occur. Therefore, it is very important to identifycracks in bridge structure effectively and provides effective information for structuraldisaster reduction projects in time.

Based on the structure of the IoT and the structural characteristics of the bridge engineering, this paper analysed the practical applications value of the IoT technology in the crack identification of bridge structures and established a bridge structure health monitoring system based on the IoT technology. On this basis, this paper also studied a digital and intelligent bridge crack detection method to improve the efficiency of bridge safety diagnosis and reduced the risk factor. First, the collected bridge crack photographs were pre-processed, the bridge crack convolution neural network classification model was established, and the model was simulated and trained using MATLAB. The bridge crack classification was obtained. The simulation results showed that the overall accuracy rate was greater than 90. [2]

Disastrous events are cordially involved with the momentum of nature. As such mishaps have been showing off own mastery, situations have gone beyond the control of human resistive mechanisms far ago. Fortunately, several technologies are inservice to gain affirmative knowledge and analysis of a disasters occurrence. Recently, Internet of Things (IoT) paradigm has opened a promising door toward catering of multitude problems related to agriculture, industry, security, and medicine dueto its attractive features, such as heterogeneity, interoperability, light-weight, and flexibility.

This paper surveys existing approaches to encounter the relevant issueswith disasters, such as early warning, notification, data analytics, knowledge aggregation, remote monitoring, real-time analytics, and victim localization. Simultaneous interventions with IoT are also given utmost importance while presenting these facts. A comprehensive discussion on the state-of-the-art scenarios to handle disastrous events is presented. Furthermore, IoT-supported protocols and market-ready deployable products are summarized to address these issues. Finally, this survey highlights open challenges and research trends in IoT-enabled disaster management Systems. [3]

In this paper a novel method, MCrack-TLS, is proposed to automatically assess cracks in concrete bridges, based on the combination of image processing and terrestrial laser scanning (TLS) technology. The images captured are orthorectified by geometric information surveyed by TLS, solving one of the major drawbacks of applying image processing for cracks characterization on large structures. After an experimental characterization, the method was tested on a concrete viaduct at IC2 road, in Rio Maior, Portugal, herein adopted as case study for onsite validation. It should be noted that capturing images with the required characteristics involves the use of different equipment, depending on both location and type of structural members. The results show the high potential of MCrack-TLS, namely its increased productivity and the possibility of record all data processed, and add it to 3D point clouds, creating 3D models of the state of conservation of bridges. In addition, it avoids the exposure of bridge inspectors to dangerous situations. [4]

In this paper they studied Cracks on the concrete surface are one of the earliest indications of degradation of the structure which is critical for the maintenance as well the continuous exposure will lead to the severe damage to the environment. Manual inspection is the acclaimed method for the crack inspection. In the manual inspection, the sketch of the crack is prepared manually, and the conditions of the irregularities are noted. Since the manual approach completely depends on the specialist's knowledge and experience, it lacks objectivity in the quantitative analysis. So, automatic image-based crack detection is proposed as a replacement.Literature presents different techniques to automatically identify the crack and its depth using image processing techniques. In this research, a detailed survey is conducted to identify the research challenges and the achievements till in this field. Accordingly, 50 research papers are taken related to crack detection, and those research papers are reviewed. Based on the review, analysis is provided based on the image processing techniques, objectives, accuracy level, error level, and the image data sets. Finally, we present the various research issues which can be useful for the researchers to accomplish further research on the crack detection. [5]

Automatic health monitoring and maintenance of civil infrastructure systems is a challenging area of research. Non-destructive evaluation techniques, such as digital image processing, are innovative approaches for structural health monitoring. Current structure inspection standards require an inspector to travel to the structure site and visually assess the structure conditions. A less time consuming and inexpensive alternative to current monitoring methods is to use a robotic system that could inspect structures more frequently. Among several possible techniques is the use of optical instrumentation (e.g. digital cameras) that relies on image processing.The feasibility of using image processing techniques to detect deterioration in structures has been acknowledged by leading experts in the field. A survey and evaluation of relevant studies that appears promising and practical for this purpose is presented in this study. Several image processing techniques, including enhancement, noise removal, registration, edge detection, line detection, morphological functions, colour analysis, texture detection, wavelet transform, segmentation, clustering and pattern recognition, are key pieces that could be merged to solve this problem. Missing or deformed structural members, cracks and corrosion are main deterioration measures that are found in structures, and they are the main examples of structural deterioration considered here.This paper provides a survey and an evaluation of some of the promising vision-based approaches for automatic detection of missing (deformed) structural members, cracks and corrosion in civil infrastructure systems. Several examples (based on laboratory studies by the authors) are presented in the paper to illustrate the utility, as well as the limitations, of the leading approaches. [6]

To assess the safety of concrete structures, cracks are periodically measured and recorded by inspectors who observe cracks with their naked eye. However, manual inspection is slow and yields subjective results. Therefore, this study proposes a system for inspecting and measuring cracks in concrete structures to provide objective crack data to be used in evaluating safety. The system consists of a mobile robot system and a crack detection system. The mobile robot system is controlled to maintain a constant distance from walls while acquiring image data with a Charged Couple Device (CCD) camera. The crack detection system extracted crack information from the acquired image using image processing.To ensure accurate crack recognition, the geometric properties and patterns of cracks in a structure were applied to the image processing routine. The proposed system was verified with laboratory and field experiments. Bridge monitoring and maintenance is an expensive yet essential task in maintaining a safe national transportation infrastructure. Traditional monitoring methods use visual inspection of bridges on a regular basis and often require inspectors to travel to the bridge of concern and determine the deterioration level of the bridge. Automation of this process may result in great monetary savings and can lead to more frequent inspection cycles. One aspect of this automation is the detection of cracks and deterioration of a bridge.This paper provides a comparison of the effectiveness of four crack-detection techniques: fast Hear transform (FHT), fast Fourier transform, Sobel, and Canny. These imaging edge-detection algorithms were implemented in MatLab and simulated using a sample of 50 concrete bridge images (25 with cracks and 25 without). The results show that the FHT was significantly more reliable than the other three edge-detection techniques in identifying cracks. [7]

Cracks on a bridge deck should be ideally detected at an early stage in order to prevent further damage. To ensure safety, it is necessary to inspect the quality of concrete decks at regular intervals. Conventional methods usually include manual inspection of concrete surfaces to determine defects. Though very effective, these methods are time-inefficient. This paper presents the use of computer-vision techniques in detection and analysis of cracks on a bridge deck. High quality images of concrete surfaces are captured and subsequently analysed to build an automated crack classification system. After feature extraction using the training set images, statistical inference algorithms are employed to identify cracks. The results demonstrate the feasibility of the proposed crack observation and classification system. [8]

Visual inspection of bridges is customarily used to identify and evaluate faults. However, current procedures followed by human inspectors demand long inspection times to examine large and difficult to access bridges. Also, highly relying on an inspector's subjective or empirical knowledge induces false evaluation. To address these limitations, a vision-based visual inspection technique is proposed by automatically processing and analysing a large volume of collected images. Images used in this technique are captured without controlling angles and positions of cameras and no need for preliminary calibration. As a pilot study, cracks near bolts on a steel structure are identified from images. Using images from many different angles and prior knowledge of the typical appearance and characteristics of this class of faults, the proposed technique can successfully detect cracks near bolts. [9]

Since the collapse of the I-35W bridge in August 2007, bridge health monitoring has become an area of intense interest. This report defines terminology related to bridge health monitoring and provides a general glossary of available monitoring systems. The glossary is meant to help readers make an informed decision by understanding how different systems function and their strengths and weakness.The authors developed a questionnaire to send to commercial companies offering monitoring systems. Of the 72 questionnaires that were sent to commercial companies, 38 companies responded and are included in this report. From information provided with these questionnaires, available commercial systems are briefly summarized. Criteria for system evaluation were developed to help the bridge owner narrow down company choices for bridge application. After the owner answers a set of questions pertaining to a particular bridge, a program developed in Microsoft EXCEL helps the bridge owner decide the best system for a particular situation. An example is provided for program clarity. Once company choice is narrowed down, additional criteria were developed to aid in final product choice. [10]

III.EXISTING SYSTEM

Several long spans, bridges in Korea and in Japan have received this real-time condition monitoring system. Nevertheless, existing system uses complex and heavy priced wired system amongst sensors in the bridge and heavy price optical cable between the bridge and the administration centre, which surges the overall expense of installation and maintenance expense of bridge condition monitoring system. The complex system also makes the installation and repair substitution procedure challenging and way expensive.

There are few bridge monitoring systems which are currently being used, but every single one of them are having some limitations which is the reason these systems are not being used on large scale. Some of the most common limitations with these systems are as follows:

- They require high installation cost.
- They generate huge amount of data.
- They require human efforts to process these data.
- Complexity is very high.

IV.COMPARISON WITH EXISTING SYSTEM

1) As compared to various bridge maintenance systems the bridge crack detection and maintenance system is different.
2) In this system we have merged 3 systems in which it consists of 3 modules ultrasonic sensor for water level detection, servo motor for closing gates and images processing for crack detection using cameras.
3) Identification of damage of the bridges has done continuously which was not possible in existing system.
4) Early warnings are given to the people who are using the bridge.
5) Bridge inspectors or engineers can get the General health status of the bridge through the data gathered by the sensors.
6) If these three modules are used separately then it is time consuming but by using them in a single project it is more useful.
7) Proposed System is time saving and consists of more safety than the existing system.
8) The instruction is given before any disaster in proposed system.

IV.PROPOSED WORK

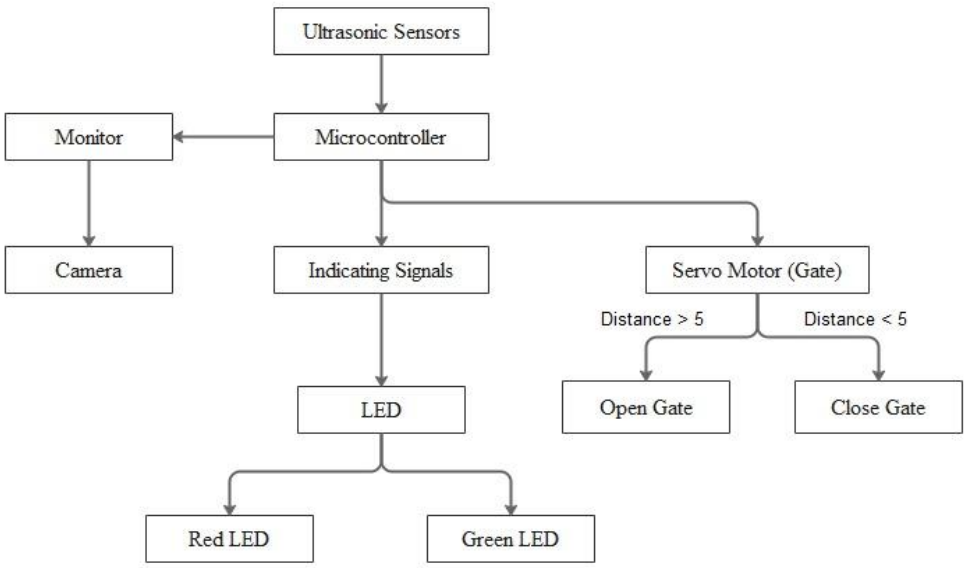

Figure 1.System Architecture

This system will give a real time response due to its effective means of image processing which detects the crack of that bridge. The water level of river is also check by this system using ultrasonic.
Crack detection and maintenance system consist of two modules.

A. Hardware module (sensors):
B. Software module (Image processing)

A. Hardware Module

1) **Ultrasonic Sensor:**Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound. Our ultrasonic sensors, like many others, use a single transducer to send a pulse and to receive the echo. The sensor determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse.Ultrasonic sensor work like indicator when of water is high it passes the signals to monitoring device.

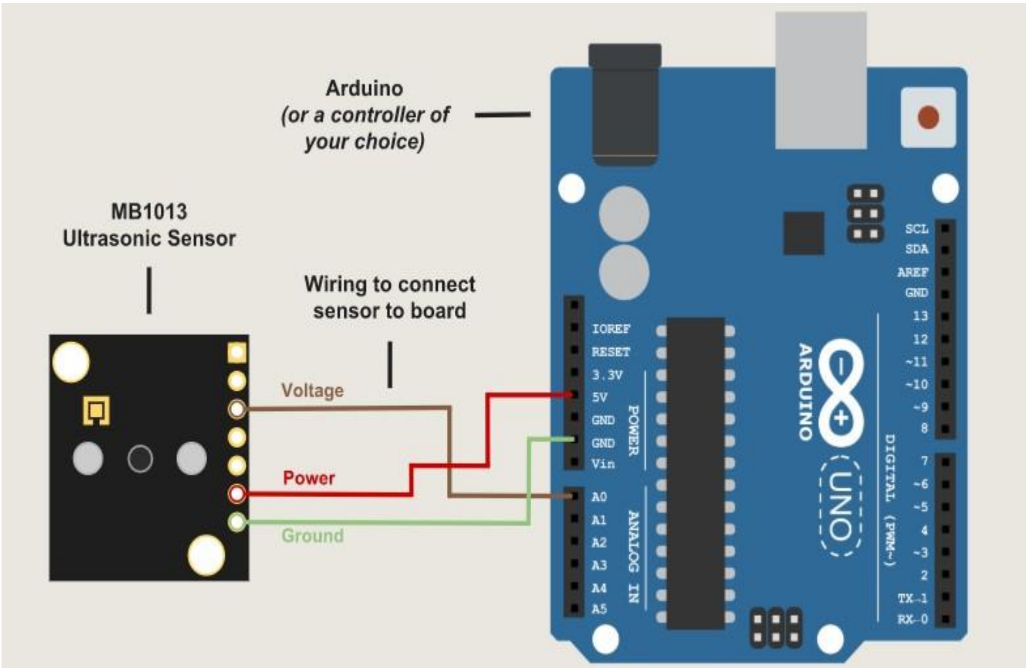

Figure 2.Ultrasonic Sensor &Arduino

Ultrasonic sensor is used for water level detection in following way:-
Step 1: Initialize.
Step 2: Detect the water level.
Step 3: If water level exceeds capacity, it alerts.
Step 4: Notify user about flooding.
Step 5: Send data to cloud server.
Step 6: Stop.

2) **Servo Motor:** Servos are controlled by sending an electrical pulse of variable width, or pulse width modulation (PWM), through the control wire. There is a minimum pulse, a maximum pulse, and a repetition rate. A servo motor can usually only turn 90° in either direction for a total of 180° movement. The motor's neutral position is defined as the position where the servo has the same amount of potential rotation in the both the clockwise or counter-clockwise direction. The PWM sent to the motor determines position of the shaft, and based on the duration of the pulse sent via the control wire; the rotor will turn to the desired position. The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns. After receiving the signals from ultrasonic sensor, servo motor rotates the Barrie gates.

B. Software Module Image Processing

1) **CNN Algorithm:**A CNN works by extracting features from images. This eliminates the need for manual feature extraction. The features are not trained. They're learned while the network trains on a set of images. This makes deep learning models extremely accurate for computer vision tasks. CNNs learn feature detection through tens or hundreds of hidden layers. Each layer increases the complexity of the learned features. Convolution network algorithms classify the image where it can be crack or not.
2) **CNN Flowchart:**Flow chart of CNN algorithm to detect cracks. It includes three steps: building crack database,

training the CNN, and testing the trained CNN classifier. To train a CNN, a large amount of raw images are taken from concrete surface. 0e collected raw images are cropped into smaller images, and then, cropped small images are manually classified into images with and without cracks. After that, training set and validation set are selected randomly from the database and imported into a CNN for training and validation. The training process generates a CNN classifier that is capable of classifying images into images with and without cracks.

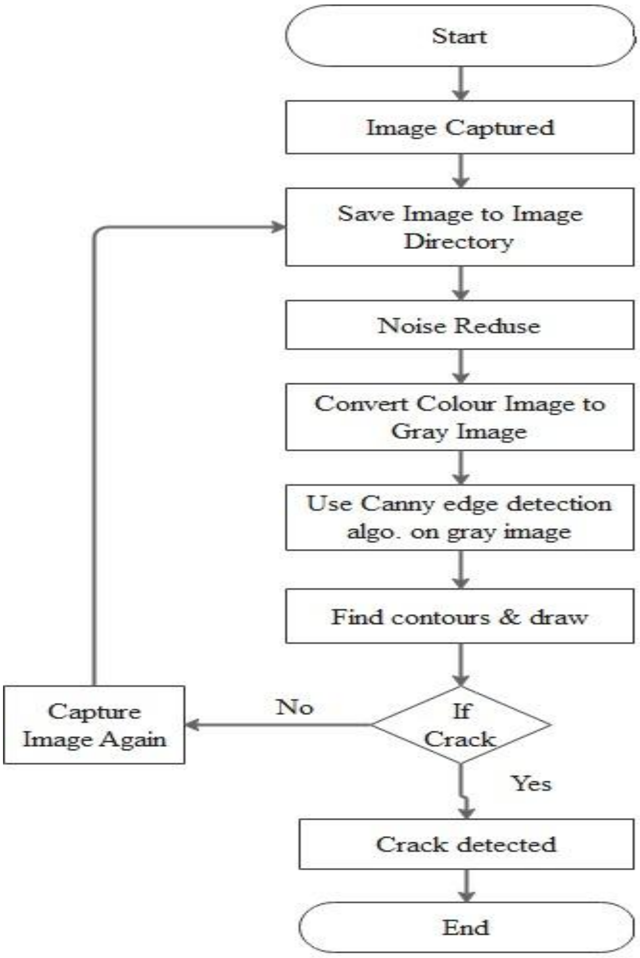

Figure 3.Flow Chart

V. RESULT

Sr. No	Output	Sensors/ Technology	Results
1	Water level checking	Ultrasonic sensor	With the help of ultrasonic sensors this system is giving the distance between the bridge and the water level of the river.
2	Gates closing	Servo motor	When the water level of the river exceeds emergency level then with the help of servo motor gates at the both end of the bridge are getting closed.
3	Crack detection	Camera, Image processing	Camera placed under the bridge is capturing images continuously and with the help of image processing the cracks on the bridge is been detected using algorithms.
4	Signals	Led bulbs	Signals are there for giving alerts. When water level of river exceeds emergency level then red light will be on and when the water level is not exceeding the emergency level then green light is on.

For the emergency situations led screen is placed at the staring of the bridge which alerts the peoples who are about to cross the bridge about the condition of the bridge and about water level of the river for users safety.

IV.CONCLUSION

Adoption of new techniques could reduce the chances of losing human lives as well as damage to large-scale infrastructures Due to both natural and human made disasters. IoT Based on the characteristics of the structure of the Internet of Things and the structural characteristics of the bridge engineering, this paper analysed the practical application value of the Internet of Things technology in the crack identification of bridge structures, and established a crack classification application system for bridge structures based on the Internet of Things technology. Aiming at the current situation that the bridge crack detection mainly relied on artificial visual inspection and the risk factor was extremely backward, a digital and intelligent detection method was studied to improve the efficiency of bridge safety diagnosis and reduced the risk factor. Firstly, image enhancement, wavelet denoising, image segmentation and other pre-treatments were performed on the collected bridge crack images. This method could effectively solve the problems of low fracture diagnosis efficiency and High risk factor in domestic fractures. Bridge safety inspections are moving toward automation and intelligence.

REFERENCES

[1] SnehalSonawane, Nikita Bhadane, SayaliZope, AshitoshPangavhane and V. S. Tidake "Design of Bridge Monitoring System based on IoT", (2018).

[2] Chuan Phamx, Luong A. T. Nguyenz, Nguyen H. Tran, Eui-Nam Huh, ChoongSeon Hong "Application of Internet of Things Technology and Convolutional Neural Network Model in Bridge Crack Detection",(2018).

[3] ParthaPratim Ray, Mithun Mukherjee, (Member, IEEE),And Lei Shu, (Senior Member, IEEE) "Internet of Things for Disaster Management:State-of-the-Art and Prospects",(2017).

[4] JValença, I Puente, E Júlio, H González-Jorge, P Arias-Sánchez “Assessment Of Cracks On Concrete Bridges Using Image Processing Supported By Laser Scanning Survey”,(2017).

[5] Arun Mohan, SumathiPoobal, “Crack Detection Using Image Processing: A Critical Review And Analysis”,(2018).

[6] Mohammad R Jahanshahi, Jonathan S Kelly, Sami F Masri, Gaurav S Sukhatme “A Survey And Evaluation Of Promising Approaches For Automatic Image-Based Defect Detection Of Bridge Structures”,(2009).

[7] Ikhlas Abdel-Qader, Osama Abudayyeh, Michael E Kelly “Analysis Of Edge-Detection Techniques For Crack Identification In Bridges”, (2003).

[8] PrateekPrasanna, Kristin Dana, NenadGucunski, BasilyBasily , ”Computer-Vision Based Crack Detection And Analysis”, (2012).

[9] Chul Min Yeum, Shirley J Dyke, “Vision-Based Automated Crack Detection For Bridge Inspection”, (2015).

[10] Andrew Gastineau, Tyler Johnson, Arturo Schultz , “Bridge health monitoring and inspections a survey of methods”, (2009).

[11] Lee JL, Wu YW, Tyan YY. "Devlopment of an IOT Based Bridge Safety Monitoring System.", Proceedings of the 2017 IEEE International Conference on Applied System Innovation IEEE-ICASI 2017 - Meen, Prior & Lam (Eds), (2017).

[12] Noel AB, Abdaoui A, Elfouly T, Ahmed MH, Ahmed Badawy, Shehata MS. "Structural Health Monitoring using Wireless Sensor Networks: A Comprehensive Survey", IEEE Communications Surveys & Tutorials, (2017), https://doi.org/10.1109/COMST.2017.2691551.

[13] S. M. Khan, S. Atamturktur, M. Chowdhury, and M. Rahman, ‘‘Integration of structural health monitoring and intelligent transportation systems for bridge condition assessment: Current status and future direction,’’ IEEE Trans. Intell. Transp. Syst., vol. 17, no. 8, pp. 2107–2122, (2016).

[14] R. Farrar, S. W. Doebling, and D. A. Nix, ‘‘Vibration–based structural damage identification,’’ Philos. Trans. Roy. Soc. London A, Math. Phys. Sci., vol. 359, no. 19, pp. 131–149, (2015).

[15] Perera, A. Zaslavsky, P. Christen, and D. Georgakopoulos, ‘‘Contex aware computing for the Internet of Things: A survey,’’ IEEE Commun. Surveys Tuts., vol. 38, no. 16, pp. 414–454, 1st Quart., (2013).

[16] M. Wollschlaeger, T. Sauter, and J. Jasperneite, ‘‘The Future of industrial communication: Automation networks in the era of the Internet of Things and industry 4.0,’’ IEEE Ind. Electron. Mag., vol. 42, no. 11, pp. 17–27, (2017).

[17] L. Atzori, A. Iera, and G. Morabito, ‘‘SIoT: Giving a social structure to the Internet of Things,’’ IEEE Commun. Lett., vol. 15, no. 11, pp. 1193–1195, (2011).

[18] E. Gelenbe, ‘‘Stability of the random neural network model,’’ Neural Comput., vol. 84, no. 12, pp. 239–247, (2014).

[19] B. Hu et al., ‘‘Convolutional neural network architectures for matching natural language sentences,’’ J. ACM, vol. 34, no. 9, pp. 2042–2050, (2015).

[20] S. Lawrence, C. L. Giles, A. C. Tsoi, and A. D. Back, ‘‘Face recognition: A convolutional neural-network approach,’’ IEEE Trans. Neural Netw., vol. 8, no. 1, pp. 98–113, (2015).