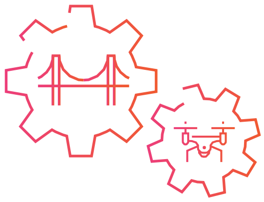
Automated Bridge Monitoring for Improved Safety

WHITE PAPER



Abstract

With the advent of new age technologies, evolving customer demands and increasing railroad traffic, the rules of rail bridge inspection have changed. Railway industry is asset intensive and our observations of financial statements of key railway players indicate that asset maintenance expenditure accounts for about a quarter of the annual revenues. In asset maintenance, bridges are some of the most complex structures of railroad network that require routine inspection to ensure smooth functioning.

However, current bridge inspection techniques fall short in productivity, accuracy, completeness and human safety. Leveraging a combination of internet of things (IoT), augmented reality/ virtual reality (AR/VR), 5G, digital twins, cloud computing, computer-aided vision systems including image-processing and predictive algorithms, unmanned aerial vehicles (UAVs) can enable frequent inspections and continuous monitoring. This will help to enhance operational efficiency and aid bridge maintenance teams in better decision-making. In this paper, we envision the role of digital technologies in automating routine bridge inspection and continuous monitoring to create exponential value.

Beginning of a New Era: Automating Rail Bridge Inspection

Today, manually inspecting rail bridges is a challenge given the aging infrastructure, inaccessible terrain, personnel safety risk and limited human visual capabilities. Automating routine bridge inspection promises to be a viable opportunity for bridge managers from a cost optimization perspective and for technology vendors from a revenue enhancement perspective.

Most of the bridges across the globe still undergo manual routine inspections. Though there are a few solutions for rail bridge inspections that have started leveraging digital technologies, most of them are in trial phases. A systematic approach (shown in Figure 1) can be followed to overcome the challenges of manual inspection and also provide a combined view of the inspections. Key components include a data acquisition system (vision sensors or drones or fixed sensors), transmission and computing mode (cloud computing or edge computing), cloud platform for computation, artificial intelligence (AI) platform for processing images and sensor data and lastly a command center for informed decision making.

One way to enable automation of routine bridge inspection is to deploy camera-mounted drones to capture the images of bridge components, transmit the data to cloud and use an image processing unit to leverage machine vision algorithms and digital 3D models to identify anomalies. This information can be used by bridge inspectors and structural experts to view and validate the health of the bridge remotely and take corrective action. Organizations can use different vision sensors to detect different types of anomalies. For instance, thermal cameras can be used to detect cracks, thermal signatures can help identify spalls, multispectral sensors can be used to identify de-coloration and laser-based image sensors can help take precise measurements. This approach provides bridge health data at the click of a button whenever there is a need for physical inspection.

For very old and critical bridges in the railway network, infrastructure managers are keen to have continuous monitoring data. To enable continuous bridge monitoring, a network of fixed smart sensors installed on bridges can be used to transmit various structural response and health parameters such as strains, loads, vibrations, displacements and temperatures to cloud and an analytics engine can be leveraged to generate anomaly reports.

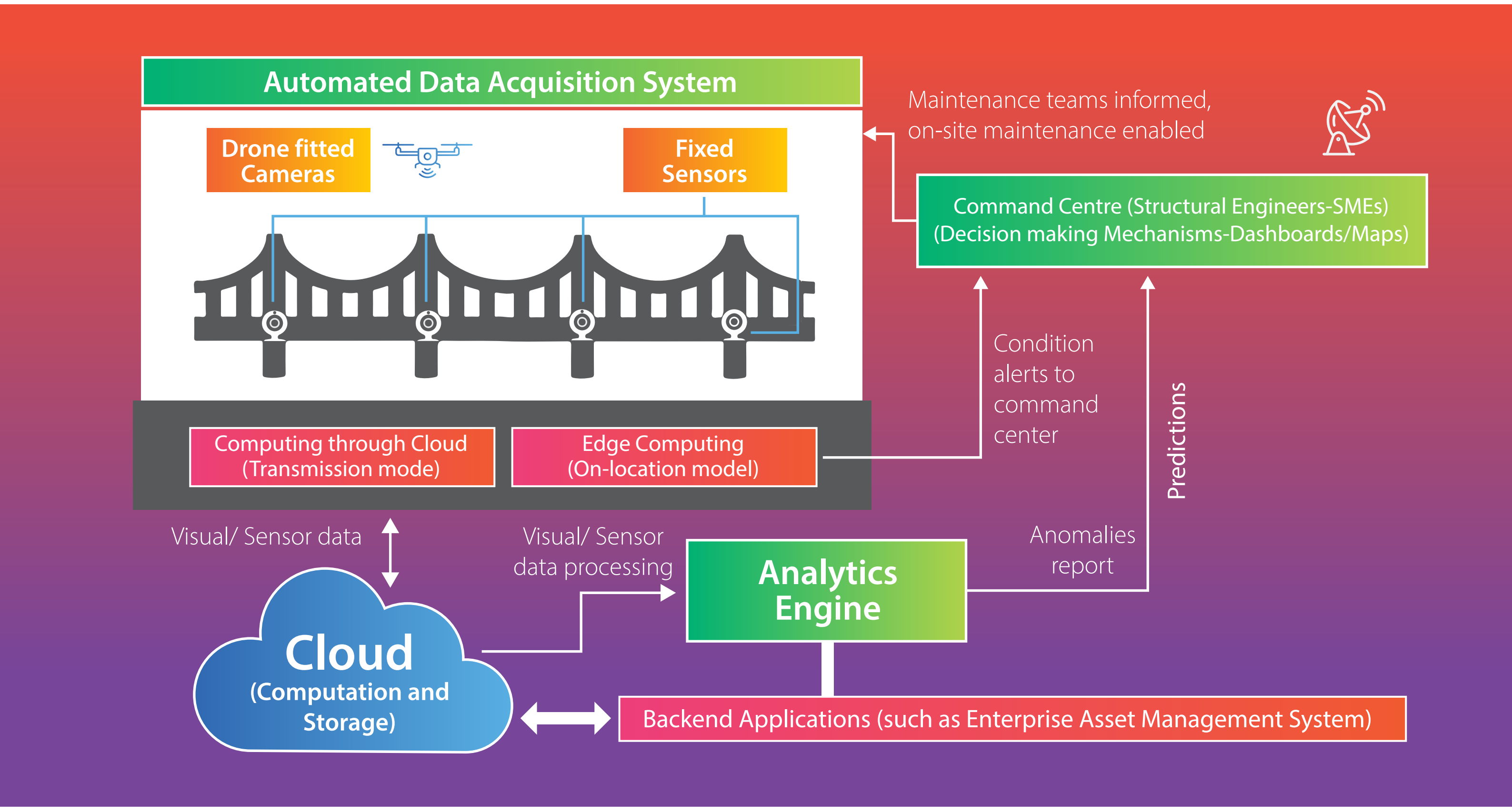


Figure 1: Rail Bridge Inspection Automation

The computation of data can be done either through cloud computing or edge computing. Leveraging technologies such as edge computing, artificial intelligence or machine learning (AI/ML), image processing algorithms and high-speed communication systems can render 3D model of bridges with current and predicted anomalies to the command center and can enable predictive maintenance.

This helps enhance safety and information accuracy while reducing idle time for train operations (systems can continue to inspect even when trains are moving over the bridge unlike manual inspection), consolidating data view from multiple systems and enabling access to historic bridge health data in digital form for trend analysis.

Quick Take

A drone can be utilized to capture 3600 images of the various components of the bridge like girders, pile caps, piers and pier caps and railway track among others. Through machine vision-based technologies, organizations can detect anomalies such as cracks and spalls. This can improve anomaly detection and augment the manual routine inspection process and accrue benefits.

Future of Bridge Monitoring: Learn, Leap and Lead

In the future, monitoring systems would be designed as integrated systems that can be implemented during the construction and over the lifetime of bridge as it offers the capability to continuously monitor the structure; validate design assumptions and improve design itself through actual structural response; and deliver a high-quality bridge. However, the rail bridge inspection solutions would be put to test in scenarios such as underwater inspection, inspection of areas with poor illumination or no lighting such as tunnels and moving obstructions and objects during the inspection. Vegetation, immovable obstructions and stringent regulations are a few roadblocks in enabling seamless implementation of automated solutions.

The future of monitoring systems largely depends on the evolution and endurance of sensor technologies. With the advent of IoT sensors and 5G deployment and the ability to enable seamless information streaming, the industry is talking about self-aware and self-orchestrated intelligent bridges. Another emerging area of interest is creating digital twin for bridges. It can help improve bridge condition monitoring accuracy through what if analysis of real-time data, improving the prediction of bridge performance.

As the global bridge inspection market grows, one can also expect the emergence of new business models. These include outsourcing of bridge inspections with IT companies, offering design and implementation of bridge monitoring systems, including bridge inspection as a service, offering cost and quality advantages. Are the rail infrastructure organizations ready for this?

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