**Creating a digital Twin of infrastructure using Unmanned Aerial Vehicles**

Abhiram A1, Uma Maheswara Rao S1, Kousar SK1, Prayash1

*Department of Civil Engineering, SRM University – AP, Andhra Pradesh, India*

Email: [subhash\_alapati@srmap.edu.in](mailto:subhash_alapati@srmap.edu.in)

**Abstract:** The use of Unmanned Aerial Vehicles in the domain of Civil Engineering gained traction in recent times. Numerous studies have assessed the capabilities of drones as supplementary tools for the monitoring of built infrastructure. With a surge in concerns about the deteriorating condition of infrastructure due to high traffic and weather conditions, this study attempts to develop a more efficient and cost-effective inspection framework that can create a digital twin. As a case study, a bridge connecting the dwellings of neerukonda and SRM University AP. The developed model can subsequently help to monitor the condition of the neerukonda bridge at higher resolution. DJI Mavic 3M, a quadcopter with an endurance time of 43 min, is used for data acquisition. Optimal flight parameters are identified in the first phase of the project by conducting a sample study. Later, the flight path is determined for the drone deployment. The obtained imagery is further used to create a 3D model using Structure from Motion (Sfm) algorithm implemented using Agiosoft Metashape software®. The conducted UAV based study resulted in capturing the reality of the study area at a resolution of 0.087 m/pixel which is reasonable to monitor the minor cracks and corrosion zones. Findings of this study underscore the cost-effectiveness of employing drones in creating digital twins of built infrastructure offering a promising avenue for enhancing infrastructure maintenance practices while simultaneously reducing operational costs.

**Keywords:** Unmanned Aerial Vehicles; Digital Twin; Orthomosaic; Quadcopter

**INTRODUCTION**

Globally, the concerns on Aging and deterioration of road infrastructure is increasing at an alarming rate. The problem is much more intense for critical infrastructure such as bridges, which are subjected to wear and tear over time due to various factors such as heavy traffic loads and weather conditions. Periodic monitoring that can aid in conducting maintenance works can immensely help in taking timely actions, which is also a fact widely acknowledged in the literature [1]. The necessity of maintenance works can be identified at the right time with help of regular inspections. Addressing issues at an early stage can prevent costly repairs or, in extreme cases, the need for bridge replacement.

Conventional periodic monitoring involves using ropes, tapes, chains, and other measuring devices and is considered a time-consuming process involving huge resources. Also, the applicability of the conventional techniques are only limited to the accessible bridges. To overcome resource-intensive processes, the use of UAVs (unmanned aerial vehicles) gained traction to conduct inspection works for bridges. Although UAV-based bridge inspections are relatively straightforward, there are still intrinsic issues in applying UAVs to bridge damage quantification [2]. Drone technology, in the recent times, helped inspectors to conduct visual assessments of infrastructure at a lower cost and with less injury risk when compared to conventional inspection methods [3]. The structural performance of bridges under both service conditions and ultimate limit states related to the occurrence of an abnormal/extreme load scenario is examined and evaluated by Mandirola et.al. (2022) [4]. The impact of various damages on the load-carrying capacity of the bridges is studied by Duque (2017) [5] with the help of simulation studies, for which the input geometry is deduced from the drone-based surveys. UAV-image-based bridge damage estimation can aid to minimize the risk involved in the inspection works. Imagery collected using drones complemented with the finite element analysis aid to analyse how damage affects the bridge's ability to carry loads [6]. The potential use of high-definition imaging to identify the cracks on bridge decks is demonstrated in the past research works [1]. Live-load performance of bridges was evaluated using UAV-based computational simulations [5]. Damage assessment of bridges was carried out by processing the drone image data with the help of deep learning-based data analytics and modelling [7]. Several forms of damage to the bridge, such as corrosion, cracking, spalling, and moisture were identified with the help of drone imagery [3]. It is essential to be able to swiftly survey large areas in the event of a nuclear disaster or radiation leak [8]. The main objective of this study was to develop a more efficient and cost-effective inspection framework that can create a digital twin of the bridge. For demonstration, the bridge near Neeru Konda is inspected abiding to the drone rules 2021.

**PROPOSED SCHEME**

The steps involved in creating the digital twin of the model are shown in **Fig.1**. As apparent from Fig.1, the study first starts with the airspace research and selection of flight path.

A diagram of a process

Description automatically generated

**Fig.1** Illustration of the steps in developing the digital twin of a bridge.

The study area is first checked thoroughly to ensure that no obstructions exist in the flight path. The considered obstructions include tall structures, electrical wires, and birds. Considering these flight parameters, the drone is deployed over the entire study area to collected aerial images captured in RGB bands. This geospatial repository is further used to create a digital twin of the bridge which can be used for thorough inspection.

**EXPERIMENTAL STUDY AND RESULT ANALYSIS**

The site selected for the study is a bridge located in Neerukonda village and it was constructed in the year 1962, which is near SRM University (AP), Guntur District, Andhra Pradesh, India. The village of Neerukonda has a population of 1,000 -1,500 people, which is present within a radius of 4 km from SRM University AP, Amrita University AP, and VIT University AP. The village connects the town Mangalagiri and other villages nearby. The selected bridge bears moderate traffic, which consists of motorcycles, cars, buses and trucks. The water body flowing through it is degrading the life of the structure due to lack of maintenance, which contains solid wastes. The water flows from Tadikonda to Neerukonda which subsequently joins river Krishna. The bridge needs proper monitoring and maintenance, which is spread over a stretch of 100ft. The deck of the selected bridge is supported by piers, which are made of rocks.

A multi spectral drone (DJI Mavic 3M model) is deployed over the region to collect the imagery. All the possible obstructions such as birds flying around, traffic by vehicles, and different weather conditions were considered before the deployment. Operating parameters are chosen by abiding the Drone rules prescribed by DGCA. The collected imagery is further processed using Structure-from-Motion (SfM) implemented using Agiosoft Metashape software® to create a three-dimensional twin of the bridge. This resulted in a total of 512 images when stitched provided an output of 0.087 m resolution. The created digital twin is shown in **Fig.2.**

A bridge over a small island

Description automatically generated

**Fig.2** Digital twin of the bridge created using the imagery collected using the drone.

The created digital twin can be used to quantify the damages such as delamination, loss of concrete sections, corrosion, cracking, spalling, and moisture.

**CONCLUSION**

This research suggests a comprehensive methodology that helps to create a digital twin of infrastructure especially which is inaccessible, empowering informed decision-making regarding maintenance and safety. Guardrail of the structure is completely damaged in few parts, which is harmful for the passengers travelling, the surface layer of the pavement also needs some repairs which improves the safety and serviceability of the structure. To ensure ongoing structural health monitoring, a regular survey schedule is established, allowing for the tracking of changes in the bridge structure's condition. By consistently applying this methodology, future data can be compared to the initial assessment, providing valuable insights into the structure's long-term health. The methodology's application extends beyond assessment; it facilitates the interpretation of structural integrity and safety. Decision-makers can determine the necessity of repairs or maintenance based on the severity of the damage. Subsequently, maintenance plans and strategies are devised, taking into account cost estimates and resource allocation.

REFERENCES

1. Hiasa, S., Karaaslan, E., Shattenkirk, W., Mildner, C., & Catbas, F. N. (2018, April). Bridge inspection and condition assessment using image-based technologies with UAVs. In *Structures Congress 2018* (pp. 217-228). Reston, VA: American Society of Civil Engineers.
2. Jeong, E., Seo, J., & Wacker, J. (2020). Literature review and technical survey on bridge inspection using unmanned aerial vehicles. *Journal of Performance of Constructed Facilities*, *34*(6), 04020113.
3. Seo, J., Duque, L., & Wacker, J. (2018). Drone-enabled bridge inspection methodology and application. *Automation in construction*, *94*, 112-126.
4. Mandirola, M., Casarotti, C., Peloso, S., Lanese, I., Brunesi, E., & Senaldi, I. (2022). Use of UAS for damage inspection and assessment of bridge infrastructures. *International Journal of Disaster Risk Reduction*, *72*, 102824.
5. Duque, L. (2017). *UAV-based bridge inspection and computational simulations*. South Dakota State University.
6. Chen, S., Laefer, D. F., Mangina, E., Zolanvari, S. I., & Byrne, J. (2019). UAV bridge inspection through evaluated 3D reconstructions. *Journal of Bridge Engineering*, *24*(4), 05019001.
7. Ayele, Y. Z., Aliyari, M., Griffiths, D., & Droguett, E. L. (2020). Automatic crack segmentation for UAV-assisted bridge inspection. *Energies*, *13*(23), 6250.
8. Brunelli, D., Pino, F., Fontana, C. L., Pancheri, L., & Moretto, S. (2020, October). DRAGoN: drone for radiation detection of gammas and neutrons. In *2020 IEEE SENSORS* (pp. 1-4). IEEE.