Unmanned Aerial Vehicle Assisted Crack Detection for Wonjudaegyo Bridge in Korea

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1.Introduction

Bridges are an important example of infrastructure. They are directly related to public safety from a socioeconomic perspective and are critical infrastructure components for transport and logistics, which are integral to economic activities. In Korea, the level of infrastructure safety perceived by the people in recent years has significantly dropped because of natural disasters as well as accidents resulting from human error. Therefore, it is imperative to secure the safety of infrastructures.

A study revealed that aged infrastructure facilities accounted for over 11% of all infrastructure facilities as of 2017 [1, 2]. Therefore, the systematic maintenance, repair, and reinforcement of aged infrastructure facilities, which are related to securing the national safety network, are critical problems. So far, good maintenance has kept infrastructure facilities free from accidents. However, going forward, the safety of infrastructure may face considerable risk because of the increasing number of aged infrastructure facilities, greater damage inflicted by natural disasters, and inefficient safety and maintenance works. Therefore, to ensure infrastructure safety, which is essential for building a content society, changes must be promptly predicted in the future and new countermeasures must be developed in response [3-5].

Taking the above in consideration for Korea, this study focuses on the investigation of the inspection measures for bridge infrastructures using Unmanned Aerial Vehicle (UAV). It demonstrates the proposed UAV-based inspection method as a case study of elevated bridge..

2. Materials and Methods

2.1 Case Study

The case study bridge infrastructure selected for the study was Wonjudaegyo Bridge located in Panbu-myeon, Wonju-si, Gangwondo Province. It was completed in 1995 and was a steel box girder bridge. Of the total of 11 shifts, images were obtained during Shifts 2–4.

(a) (b)

Figure 1. Wonjudaegyo Bridge, Korea: (a) Aerial view with control point locations; (b) Installation of control points before flying UAV.

2.2 UAV used

Table 1. Specifications of UAV used.

UAV		Specifications	Descriptions
	Body	Wing	Rotary wing
		Length × width × height	105 × 105 × 45 cm
		Flight time	Approximately 25 min
	Camera	Resolution	24 MP
		Maximum image size	6000 × 4000
		Takeoff/landing	Vertical
		Gimbal	Three-axis
		Weight	3.4 kg
Leica/Aibot		Photographing the substructure	Possible (with an on-top gimbal)

2.3. Method

In First a set of control points were established to register the images. And then GPS survey was done to get their precise coordinate. After that UAV was flown to take pictures. For processing of the obtained UAV images, PIX4D Mapper software was used. For the coordinate system, the international system of WGS94 coordinates was used, and the variable values of the camera used for recording were considered for the processing. Figure 2 shows a flowchart for the general UAV image processing.

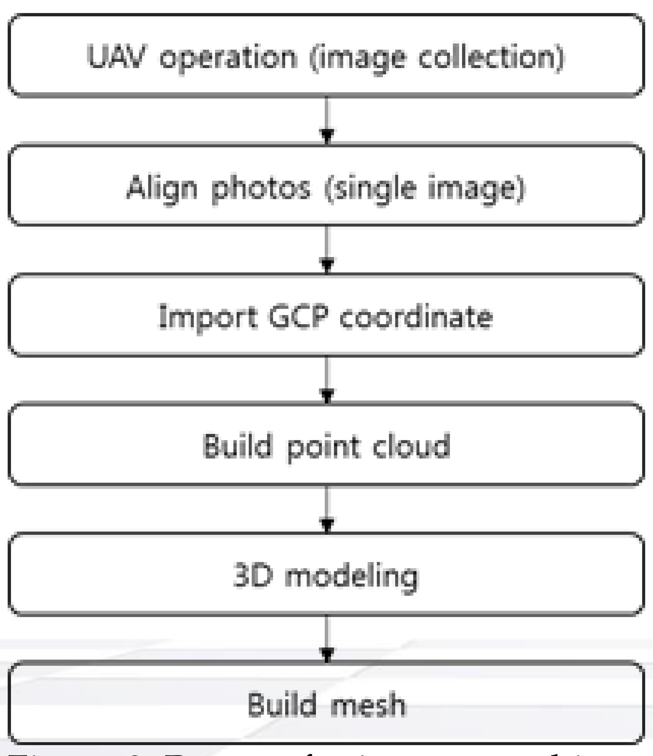
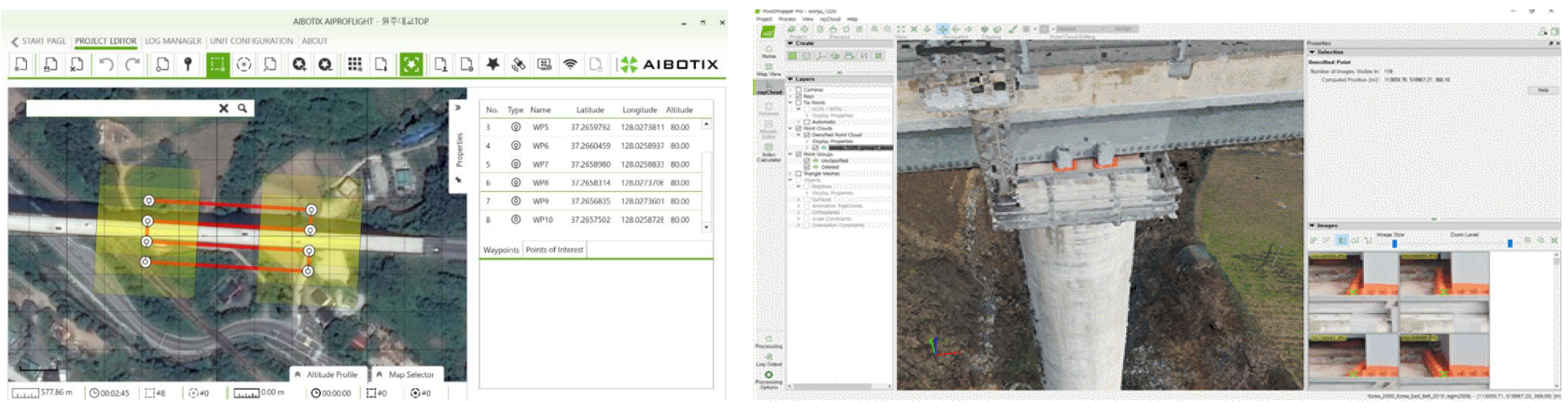


Figure 2. Process for image matching.

3. Results

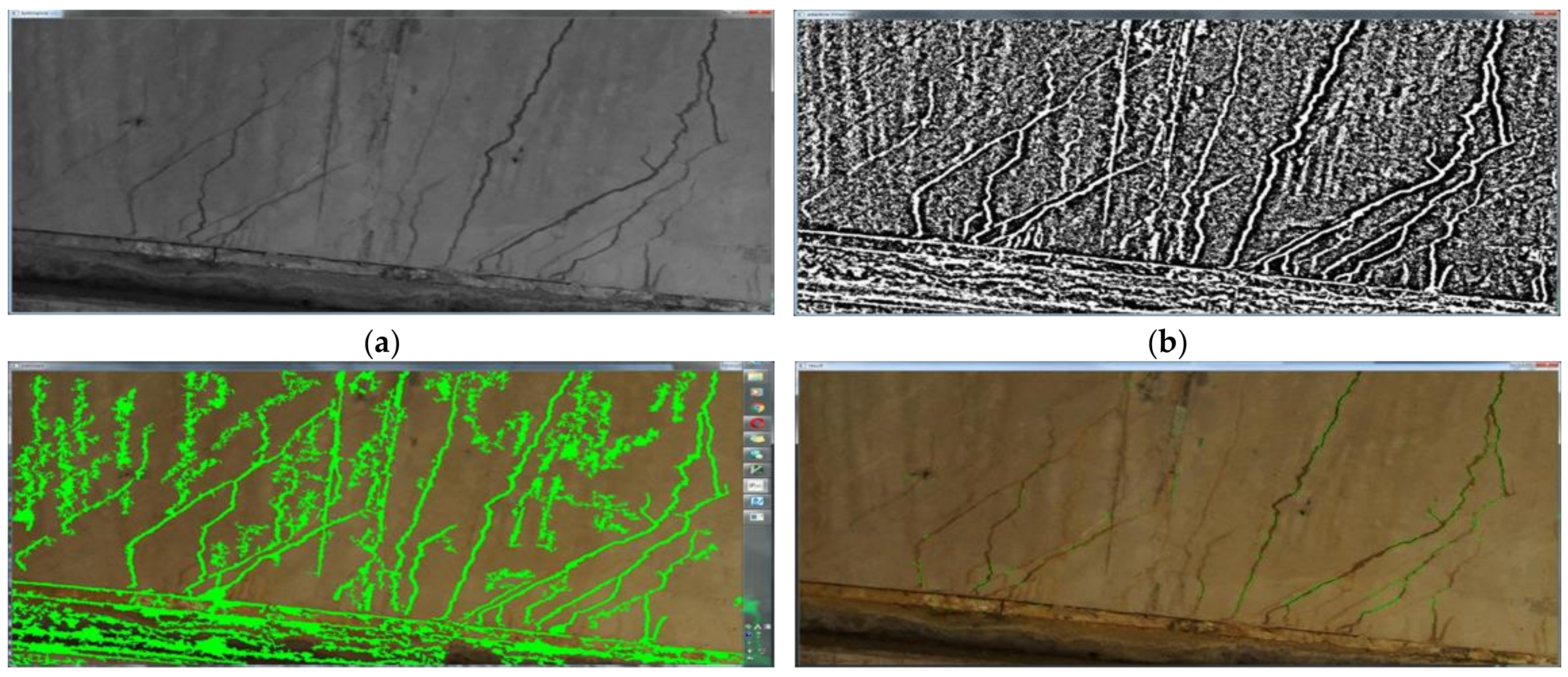
After choosing the case study bridge and establishing the control points, flight planning was done for UAV image capturing. Figure 3a shows the four strips of flight path planned for the bridge area and 3b shows a sample of image in PIX4D software.



(a) (b)

Figure 3. UAV based monitoring in Wonjudaegyo Bridge, Korea: (a) Establishing UAV flight plan; (b) Sample image taken by UAV.

For effective crack detection, image data were extracted from channel L (luminance) and Gaussian adaptive threshold methods were performed. Based on which, area boundaries of the cracks were extracted. Figure 4 shows all the stages of images taken to extract the cracks in the concrete bridge surface. For the comparison of the results, the final cracks were overlaid to the actual image of the surface (Figure 4d). And the results were good enough in term of cracks detected. This shows that UAV can save cost and time in efficient structure health monitoring such as bridges that are expensive to inspection and maintenance.



(a) (b) (c) (d)

Figure 4. Results of crack detection in the Wonjudaegyo Bridge, Korea: (a) Data extracted from channel L (luminance); (b) cracks using Gaussian adaptive threshold method; (c) cracks after extracting area boundaries; (d) final cracks overlaid with image.

4. Conclusion

This study considered the use of a UAV, which has advantages in terms of economy, convenience, and data acquisition in inaccessible areas, as an alternative to the existing methods. We selected Wonjudaegyo Bridge as the case study and used a rotary-wing UAV named Aibotix, which is manufactured by Leica. The images obtained by the UAV were displayed in a 3D viewer after an image matching process. Thus, the maintenance work could be carried out from any location. Gaussian adaptive method on luminance channel image was applied to inspect the matched images. Crack detection was carried out, and the results were analysed based on the bridge inspection. The proposed UAV-based method was found to be better in terms of cost, time and convenience.

5. References

1. Park, K.H.; Sun, J.W. Development of real-time bridge inspection application connected with bridge management system. *Journal of the Korea Academia-Industrial cooperation Society* **2015**, *16*, 7893-7901, DOI: 10.5762/KAIS.2015.16.11.7893.
2. Park, K.H.; Sun, J.W. Development of bridge life-cycle management system based on information and communication technology. *Journal of the Korea Academia-Industrial cooperation Society* **2016**, *17*, 13-20, DOI: 10.5762/KAIS.2016.17.10.13
3. Metni, N.; Hamel, T. A UAV for bridge inspection: visual servoring control law with orientation limits. *Automation in Construction* **2007**, *17*, 3-10, DOI: 10.1016/j.autcon.2006.12.010.
4. Oh, J.; Jang, G.; Oh, S.; Lee, J.H.; Yi, B.; Moon, Y.S.; Lee, J.S.; Choi, Y. Bridge inspection robot system with machine vision. *Automation in Construction* **2009**, *18*, 929-941, DOI: 10.1016/j.autcon.2009.04.003.
5. Mohan, A.; Poobal, S. Crack detection using image processing: a critical review and analysis, *Alexandria Engineering Journal* **2017**, in press, DOI: 10.1016/j.aej.2017.01.020.

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