Vision-based guide system for rendezvous of PC bridge members using a planar marker

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Abstract Construction industry is one of the main areas involved in several environmental issues like emission of carbon dioxide, energy consumption, and environmental destruction. Therefore there have been diverse efforts to overcome these problems in terms of material, construction method, and even concepts. PC (Precast Concrete) technology can be considered as green technology in that it can reduce construction time in which the problems mentioned above can be relieved. This paper introduces a guide system for rendezvous of PC members by estimating 6-DOF of the members and visualizing its movement, which can more accelerate the speed of construction.

Keywords: 6-DOF, displacement, vision, precast concrete, construction, rendezvous.

1 Introduction

Rapid construction brings us a lot of benefits with reduced traffic disruption, improved work zone safety, reduced environmental impact, improved constructability, increased quality, and lower life-cycle cost which also can be advantages of PC construction method because main characteristic of that is reduced on-site construction time. PC members are fabricated from off-site manufacturing facility, transported to the construction site, and located in right position by a crane. The time required for PC construction is very low comparing on-site construction process. Not only in construction time but also repairing process PC members are useful especially for roads, bridges, or other infrastructures that affect the traffic congestion since these facilities need regular maintenance dealing with several damages. The main objective of the vision-based guide system is to boost PC construction process by helping crane operator to track location of PC members in real time.

2 Marker and camera-based pose estimation

Marker is one of the popular technologies in augmented reality society and their application is very useful to interact between digital world and physical real world. As shown in Figure 1, a planar marker is projected on the image plane of the camera and twelve edge points of the marker are extracted by image processing algorithm.

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With known pattern and size of the marker camera pose information against the marker can be calculated.

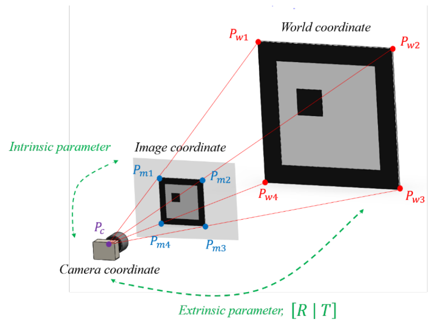

Figure 1: Geometry view of the planar marker

3 Marker-based displacement measurement system

As explained above, the relative 6-DOF between the camera and the marker can be calculated. Our system is developed for rendezvous of construction members, especially PC bridge slabs. Once the camera and the marker are installed to the slab and the beam of a bridge, respectively, and precisely aligned, the relative pose between the PC slab and the beam of the bridge can be estimated as shown in Figure 2.

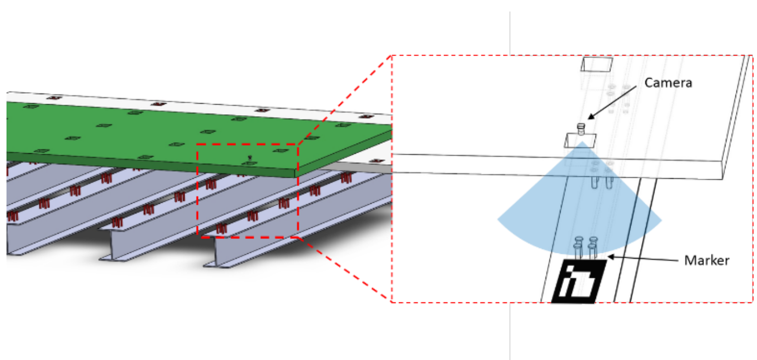

Figure 2: Marker system for a PC slab of a bridge.

Since the rectangular opening of the PC slab and the bolts connected to the beam should meet each other, a camera is installed in the rectangular opening and a marker is placed near the bolts. This installation method can minimize the hindrance of illumination in that camera looks down to the ground. One module of camera and marker guarantees the rendezvous of only one pair of the rectangular opening and bolts. Considering the size of normal PC slabs that is about 8,000 to 10,000 mm, one pair of camera and marker module is not enough to cover the whole structure. That's the reason why the multiple modules are needed. After that the estimated information will be reconstructed by computer vision library like OpenCV or OpenGL for visualization.

4 Experimental test and the results

The performance of the marker system was evaluated by two motorized motion stages, one is for translation and another is for rotational displacement. The camera was installed 500mm distance from the marker where is the closest distance to extract a marker and guarantees highest accuracy. A translational motorized stage and a rotational motorized stage travel 5, 10, 15 mm and 5, 10, 15°, respectively. The average of translation error was below 0.02mm which satisfies the requirement as a guide system for rendezvous. Although translation error depending on the rotation occurs, that is about 0.25mm/1° on average, it is found that the error level is low enough to estimate displacements of construction members.

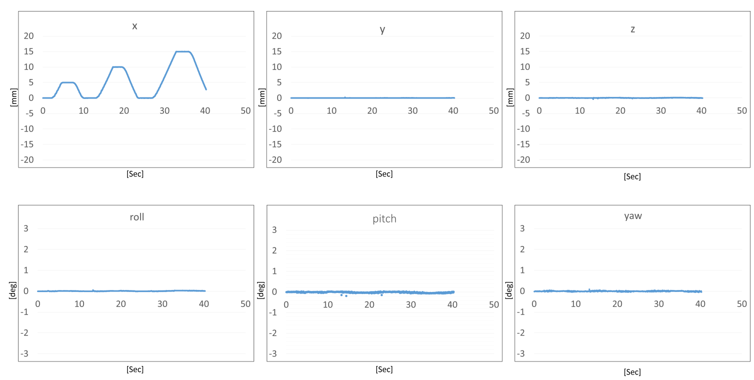

Figure 3: Translation and rotational displacements from dynamic translation experiment along x-axis

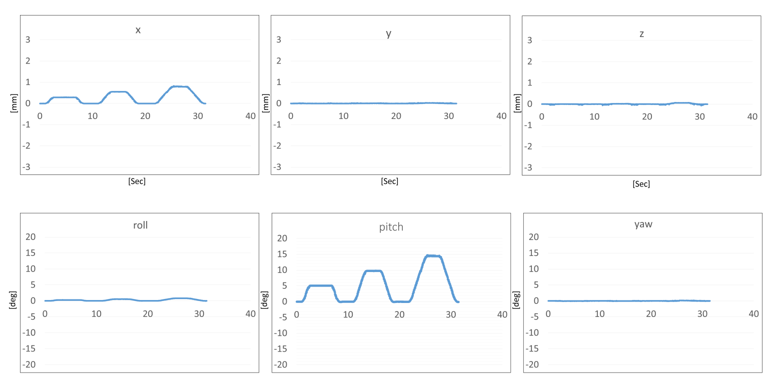

Figure 4: Translation and rotational displacements from dynamic rotation experiment along y-axis

5 Acknowledgement

This research was supported by a grant (13SCIPA01) from Smart Civil Infrastructure Research Program funded by Ministry of Land, Infra-structure and Transport (MOLIT) of Korea government and Korea Agency for Infrastructure Technology Advancement (KAIA).

6 References

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