The 6th International Conference on Construction Engineering and Project Management (ICCEPM 2015)
Oct. 11 (Sun) ~ 14 (Wed) 2015 • Paradise Hotel Busan • Busan, Korea
www.iccepm2015.org

A Conceptual Design of Around View Monitoring System for Construction Equipment

Dong Jun, Yeom[1] and Jung Hoon, Seo[2] and Jong Hyun, Hong[3] and Young Suk, Kim[4]

Abstract: Despite the improvement of productivity and cost, the operating of such equipments yet has been recognized as a 3D business which is a low wage and poor working environment business field. Accordingly, the number of such operators has been decreasing by time. Especially, construction equipment demands higher controlling skills and occasionally involved in critical accidents. Therefore, this study aims to suggest a conceptual design for an construction equipment Around View Monitoring system that visually assists the operator for more efficient operating. It is expected that the application of such technology for a construction equipment highly improves the productivity and work quality, moreover, prevents disastrous accidents that occur to labors.

Keywords: Construction Equipment, Around View Monitoring(AVM), Conceptual Design

I. Introduction

A. Background

Numerous innovative construction equipments have been developed during the last decade due to the increase of size and complexity of construction projects. Despite the improvement of productivity and cost, the operating of such equipments yet has been recognized as a 3D business which is a low wage and poor working environment business field. Accordingly, the number of such operators has been decreasing by time. Especially, construction equipment demands higher controlling skills and occasionally involved in critical accidents. Therefore, this study aims to suggest a conceptual design for an construction equipment AVM(Around View Monitoring) system that visually assists the operator for more efficient operating. It is expected that the application of such technology for a construction equipment highly improves the productivity and work quality, moreover, prevents disastrous accidents that occur to labors.

B. Scope and Method

The scope of this study is limited to creating a conceptual design of an around view monitoring (AVM) system for construction equipment, by using the following method:

1) By analyzing problems of the AVM system for passenger cars, requirements for the AVM system for construction equipment were found, and then, the presentation information of the construction equipment AVM system to improve efficiency of construction equipment operation was defined.
2) The optimal position of CCD cameras for the construction equipment AVM system was analyzed.
3) To create the optimal conceptual design of the construction equipment AVM system, hardware and system design was created.

II. Definition of Construction Equipment AVM System and Analysis of the Optimal Position of CCD Cameras

A. Definition of Presentation Information of Construction Equipment

In this study, to develop an AVM system suitable for construction equipment, first, problems of the conventional AVM system for passenger cars were analyzed. The result showed that, as the application algorithm of the relevant technology is based on passenger cars instead of excavators, the top-view area is somewhat small. Also, features of construction equipment (boom, arm, bucket, etc.) could not be expressed in the AVM video. Also, in earthwork, position of construction equipment changes according to the ground slope and curves and it might cause serious error (distortion) in the images, considering characteristics of AVM technology. Therefore, in this study, based on the problems identified earlier, presentation information required for developing a construction equipment AVM system was defined as follows:

1) Developing Distortion Correction Technology for Long Range Image

Construction equipment (including excavators and dozer) is larger than passenger car. And it is necessary to provide long-range image (visual information) with minimal distortion to the operator in order to improve work efficiency and safety during other work than operating (such as excavation, pause, crushing, etc.). Therefore, distortion correction technology for a long range image must be developed.

2) Securing Top-View Area for Construction Equipment Specifications

It is necessary to develop an omnidirectional monitoring (AVM) technology for construction equipment to provide an AVM video of the top view with minimal distortion

[1] Ph.D Candidate, Dept. of Architectural Engineering, Inha University, Incheon 402-751, Korea, dj09051@inha.edu
[2] Master Candidate, Dept. of Architectural Engineering, Inha University, Incheon 402-751, Korea, circlering@naver.com
[3] Master Candidate, Dept. of Architectural Engineering, Inha University, Incheon 402-751, Korea, hsk6215@gmail.com
[4] Professor, Dept. of Architectural Engineering, Inha University, Incheon 402-751, Korea, youngsuk@inha.ac.kr (Corresponding Author)

within the working radius.

3) Developing Image Correction Technology According to Construction Equipment Position

It is necessary to develop a technology to correct images according to the position of construction equipment so that optimal image can be provided to the operator of construction equipment, by correcting the recognized range of the image according to the position change (angle) of construction equipment.

4) Reflecting Construction Equipment Features (Boom, arm, bucket movement, turning radius, etc.)

It is necessary to develop monitoring technology that will enable a construction equipment operator to monitor the state of construction equipment (such as boom, arm, bucket movement, turning radius, and distance from the ground) on the AVM system screen as in Fig 1 and improve efficiency and productivity.

Fig 1. Construction Equipment Working Status Monitoring example

B. Analysis of Optimal Installation Position of Construction Equipment Around-View Camera

1) Possible Positions of Camera According to Specifications of Construction Equipment

In this study, to provide image from the construction AVM system, construction equipment was classified according to specifications and optimal position to install cameras was analyzed. The result shows that, according to equipment specifications, 2.5m to 3.4m on the front, 1.5m to 2.5m on the side, and 1.5m to 2.5m on the rear are the optimal positions to install cameras. And, the range of vision recognition was 1.9m to 5.0m on the front, 2.8m to 6.7m on the side, and 1.9m to 3.6m on the rear.

2) Test-bed Image Acquisition Test

To test image acquisition according to equipment specifications, a test-bed was designed and the position of camera was varied between 1.5m and 2.5m and an image acquisition test was conducted based on the test-bed. The result shows that, to realize AVM images, a fish-eye lens with over 180° of angle of view must be used, and an image correction algorithm for the fish-eye lens will need to be developed (Fig 2-a).

3) Test of Top-View Acquired from Fish-Eye Lens

By using the image acquired from a fish-eye lens at 2.3m, a top-view correction test was performed. Correction only based on perspective transformation inevitably included distortion in the top view image, and the distortion was worse towards the side. Therefore, in this study, it was found that an image correction algorithm that includes both perspective transformation and distortion correction need to be developed and applied to development of a construction equipment AVM system (Fig 2-b).

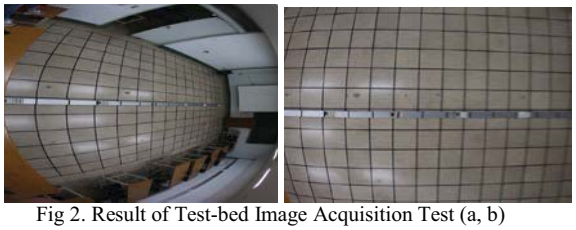

Fig 2. Result of Test-bed Image Acquisition Test (a, b)

III. Proposal of Conceptual Design of Construction Equipment AVM System

In this study, hardware required for a construction equipment AVM system was formed and the system hardware design was proposed as in Fig 3. The proposed system processes images acquired from four cameras and position data of construction equipment acquired from the tilt sensor in the AVM processor.

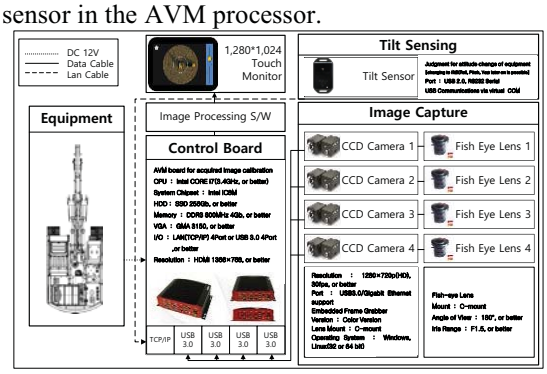

Fig 3. Construction Equipment AVM System hardware design

IV. Conclusion

In this study, to develop an AVM system suitable for features of construction equipment, four considerations, i.e., 1) developing distortion correction technology for long range image, 2) securing top-view area for construction equipment specifications, 3) developing image correction technology according to construction equipment position, and 4)reflecting construction equipment features(boom, arm, bucket movement, turning radius, etc.) were defined. Also, the optimal installation position of a camera according to construction equipment (excavator) specifications and vision recognition range was analyzed. The hardware for construction equipment AVM system included AVM processor, CCD camera (4EA), fish-eye lens (4EA), tilt sensor (1EA) for the construction equipment AVM system. And, based on angle values obtained from excavator joints, the optimal UI design for a construction equipment AVM system was designed. Development and subsequent application of such construction equipment AVM system will be able to improve productivity and efficiency of overall construction equipment.

Acknowledgements

This research was supported by a grant (14SCIP-B079344-01) from Construction Technology Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.