

# Wrap-around View Equipped on Mobile Robot

Sun Lim, Sewoong Jun, and Il-Kyun Jung

**Abstract**—This paper presents a wrap-around view system with 4 smart cameras module and remote motion mobile robot control equipped with smart camera module system. The two-level scheme for remote motion control with smart-pad(IPAD) is introduced on this paper. In the low-level, the wrap-around view system is controlled or operated to keep the reference points lying around top view image plane. On the higher level, a robot image based motion controller is utilized to drive the mobile platform to reach the desired position or track the desired motion planning through image feature feedback. The design wrap-around view system equipped on presents such advantages as follows: 1) a satisfactory solution for the FOV and affine problem; 2) free of any complex and constraint with robot pose. The performance of the wrap-around view equipped on mobile robot remote control is proven by experimental results.

**Keywords**—four smart camera, wrap-around view, remote mobile robot control

## I. INTRODUCTION

THE research of remotely operated or autonomous mobile robots has recently been developed as a focus within the robotics community[1]~[3], wherein a kernel problem is to detect the surrounding environment by various sensors, so as to make proper decisions to fulfill a given task. With the rapid development of image processing, control theory, and computer vision, visual image plane feedback control, usually termed as visual servoing or vision-based control[4]~[7], has been introduced into robotic systems to increase its intelligence and flexibility. These systems have one camera and pan module for yaw motion. Visual servoing by mounting the motor, if the feature point is always in the middle(or center rage) so that the image plane, so the following issues are to maintain.

As pointed out frequently, current visual servoing system still face several key drawbacks, such as oversensitivity to camera calibration error and image noise, difficulty in keeping the target in the field of view,i.e., the so-called FOV problem, low servoing efficiency, failure of path planning in complex environments, and so on.

This paper focuses on the mobile robot platform application in which four cameras in used to feedback image plane and track the planar motion of mobile robot in the real 3-dimensional workspace.

Sun Lim is with the Korea Electronic Technology Institute, Republic of Korea (phone: 82-10-3540-9865; fax: 82-31-621-2866; e-mail: sunishot@keti.re.kr).

Sewoong Jun is with the Korea Electronic Technology Institute, Republic of Korea (phone: 82-10-9767-3102; fax: 82-31-621-2866; e-mail: daniel@keti.re.kr).

Il-Kyun Jung is with the Korea Electronic Technology Institute, Republic of Korea (phone: 82-10-3160-2165; fax: 82-31-621-2866; e-mail: mickey3d@keti.re.kr)

For this purpose, the smart KETI-CAM system and wrap-around view system are proposed. The main advantage of the proposed system is that using the image information around the robot user can operate easily with smart PAD.

The paper is organized as follows. Section II describes the introduction of smart KETI-CAM and wrap-around view system. In Section III, the basic remote control with wrap-around view system is presented for the convenience of the readers. The basic and problem is then described. The conclusions are finally given in Section IV.

## II. WRAP-AROUND VIEW SYSTEM

### A. Smart KETI-CAM

The figure described the developed the smart KETI-CAM module. This system consists of a total of three boards. The core board is the image processing part which is consisted of the Analog Device's BlackFin core and memory. BlackFin core is utilized for image capture and image translation. The camera intrinsic and extrinsic parameter is ported and self-side wrap-around view is configured by the following sequence.



Fig. 1 Smart Camera Module,i.e., Smart KETI-CAM

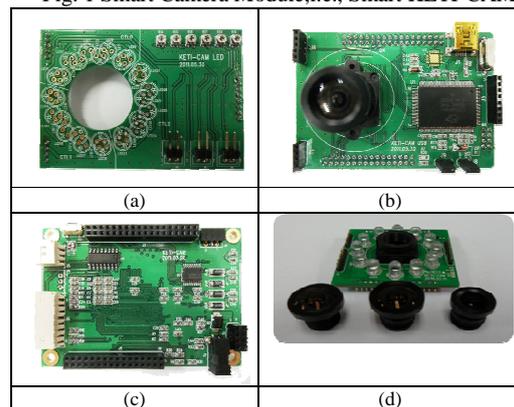


Fig. 2 Smart KETI-CAM Hardware Configure.

(a) Smart KETI-CAM LED Part, (b) Smart KETI-CAM Core Part, (c) Smart-KETI-CAM External Interface Part, (d) Smart-KETI-CAM Multi-Lens System

By the CMOS sensor, the image is captured on 320x240 pixels or 640x480 pixels. The given image is calibrated by camera two parameters. Thus the original lens distortion is corrected this processing. The figure 3 is the obtained result image plane with lens distortion correction. Then, the corrected image is converted by the homography matrix. As shown in Fig. 4, the camera side view is converted on top-ward view. The detail homography matrix is omitted. The homography matrix contains the translation and rotation information between the current and desired robot coordinate systems.



Fig. 3 Image-Plane with lens distortion correction  
Left- raw image plane, Right- lens distortion correction image

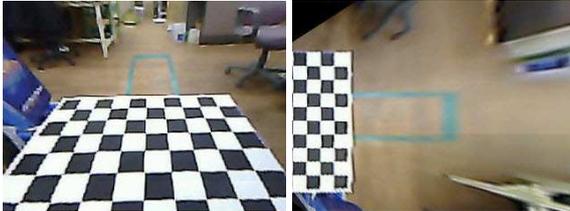


Fig. 4 Image-Plane with Top ward view  
Left-camera view, Right- Top ward view



Fig. 5 Equipped Smart KETI-CAM and calibration program  
Left-Smart KETI-CAM, Right- calibration program

**B. Mobile Robot Platform with Smart KETI-CAM**

The smart camera module described detail in the previous section was used conversion the video images recorded by four cameras, which are mounted in the front, rear, and on the left and right sides of the mobile robot. Figure 6 is described the wrap-around view system equipped mobile robot platform and Figure 7 depict the calibration and homography matrix which is computed using checker board.

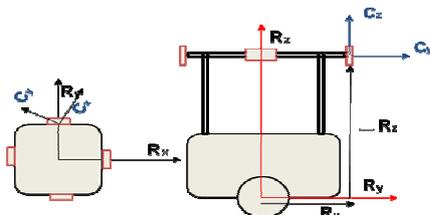


Fig. 6 Smart KETI-CAM equipped mechanism

The parameters that are written in the figure are omitted.



Fig. 6 Smart KETI-CAM equipped on mobile platform

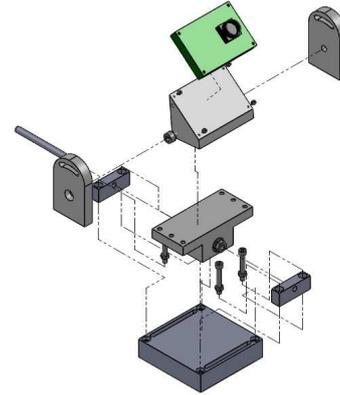


Fig. 7 Smart KETI-CAM equipped mechanism

**C. Wrap-around view system**

Smart KETI-CAM converts the video images recorded by four cameras, which are mounted in the front, rear, and on the left and right sides of the mobile robot. Figure is described the wrap-around view system equipped mobile robot platform. The conversion and synthesized images into Top view can be achieved via projection conversion which is calculated by the transformation and rotation homography matrix.

The images are projected onto a flat surface equivalent to the floor surface. Although this system is effective for visualizing object around the robot, it has a drawback in that since the images are projected on a flat surface, the shape of objects far away from the robot platform tend to be blurred.

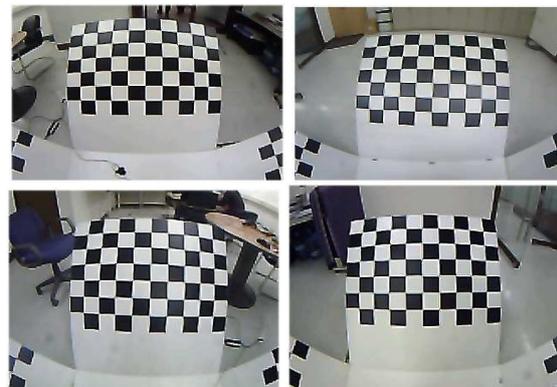


Fig. 8 Four-camera images

The image plane from the individually smart KETI-CAM are projected or converted onto a virtual 3-D curved surface and the images on that surface are converted into those seen from any desired point of view using the technology of 3-D virtual projection and point of view conversion.

### III. BASIC REMOTE CONTROL WITH WRAP AROUND VIEW SYSTEM

The smart-PAD controller program describes the image information around the robot. As the wrap-around view system covers a field of view of 360 degree with top-ward view. Figure 9 shows a smart PAD-GUI and real image plane. The navigation and reference trajectory is input from the user. The input methods are click and drag/drop on the touch-screen of smart-PAD. As robot move the real world in real-time image information on the screen is updated around the robot. Previous image information is stored and displayed as a fixed form. Thus, information is passed around the environment in real-time updates may not be. In our experiments the non-holonomic robot navigates between rooms in order to reach the target point.

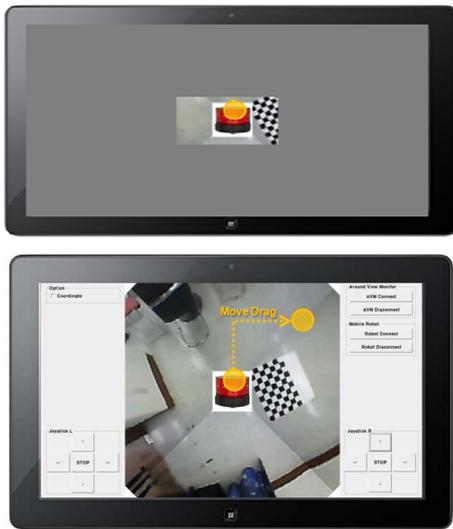


Fig. 9 Smart-PAD GUI and image plane information around robot

### IV. CONCLUSION

In this study, the wrap-around view system was proposed for the free-collision, monitoring and easy remote control the mobile robot platform. The robot equipped with the wrap-around view module can be tracked the complex environment which lie the much obstacles. From our experiments, the following conclusions are drawn:

- 1) The visual information of 360 degree around the robot can be clearly seen.
- 2) The robot around an obstacles and feature point can be found easily.
- 3) The position of obstacles and object is not uniquely related to the robot pose but depends on the camera view.
- 4) The remote robot mobile control is intuitively steerable and operated with image plane of around robot.

Experiments have been performed to validate the proposed the wrap-around view system and remote control. Future work will target to extend the simultaneous localization and mapping with wrap-around view module.

### ACKNOWLEDGMENT

This work was supported in part by Dae-Kyung wide economies leading industrial Program (A000700032)

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