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Development of Automatic Position-adjustable Elevator for Workboat

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This paper concerns an automatic position-adjustable elevator that realizes easy and safe passage between a workboat and a floating structure or an ocean platform. The elevator attached to the workboat is controlled so as to reduce the relative displacement between the workboat and the structures. Shown are the 3-D motion measurement by image processing technique and some successful results of model experiments.

NOMENCLATURE

c_x, c_y:	principal point of image (point perpendicular projection of optical center onto image plane)
D:	differential gain
f:	focal length
H:	wave height
L:	length between perpendiculars of model workboat
P:	proportional gain
$\boldsymbol{R}(\alpha, \beta, \gamma)$:	rotation matrix
(r, c):	pixel coordinate system
s_x, s_y:	horizontal and vertical distance of sensor elements on CCD chip of camera
$\boldsymbol{T}(t_x, t_y, t_z)$:	translation vector
t:	time
(u, v):	image plane coordinate system
V_{in}:	input to amplifier of AC servo system
(X, Y, Z):	world coordinate system
(x, y, z):	camera coordinate system
Ye:	motion of elevator
Ye_a:	amplitude of motion of elevator
Yr:	relative displacement between workboat and buoy
Yr_a:	amplitude of relative displacement between workboat and buoy
ΔY:	error of motion of elevator
ε_{Ye}:	phase of motion of elevator to relative displacement between workboat and buoy
κ:	parameter of lens distortion (radial distortion)
λ:	wavelength
ζ:	incident waves

INTRODUCTION

Floating structures, buoy systems (Fig. 1) (Koterayama et al., 2003) and ocean platforms (Fig. 2) (Koterayama et al., 1992) are widely used in oceanographic investigation and observations. The operators have to carry out steady maintenance to assure high quality data. However, it is difficult and dangerous to move from a workboat to a platform because both are swung by ocean waves.

Fig. 1 Workboat and ocean observation buoy

We developed an automatic position-adjustable elevator so as to realize easy and safe passage. The elevator attached to the workboat is controlled to reduce the relative displacement between the workboat and the other structure. The relative displacement is measured by image processing technique and sent to the elevator controller. There are various methods of 3-D motion measurement (Tsai, 1987; Dhome et al., 1989; Weng et al., 1989; Ayache et al., 1991; and Papadimitriou et al., 1996). One of the famous methods is the use of a stereo camera system (Fossen, 2002). This method requires 2 cameras and calculation of a transformation matrix (Fossen, 2002) to obtain the 3-D motion of a rigid body from the 3-D positions of the 3 targets on the body. While this measurement system is complicated, there is an advantage in that it can measure rotational motion of 180° degrees or more. So, in this study, 3-D motion measurement by the Pose Estimation method which uses only one camera is used (Quan et al., 1999; MVTec Software GmbH 2003). This method is simple although it cannot measure movement of a large angle.

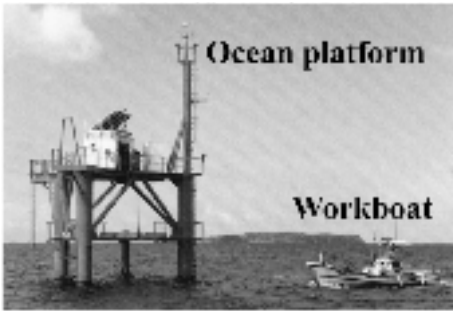

Fig. 2 Workboat and ocean platform

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KEY WORDS: Position-adjustable elevator, control, image processing, workboat, ocean observation buoy, model experiments, robustness of image processing.