APPLICATION OF IMAGE PROCESSING TO DETECION OF WORKERS AROUND HEAVY EQIPMENT

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ABSTRACT: This paper describes the application of machine vision technology to prevention of collision accidents with heavy equipment such as hydraulic excavators and cranes. The images of the back side of heavy equipment with cameras which can take a picture with 180 degree shooting angle were captured and the worker was detected by developed color image processing algorism. A laser range finder and an orientation sensor were used to calculation of the distance from heavy equipment to worker who is detected from captured image.

***Keywords**: Safety Management, Collision Accident, Image Processing, Laser Range Finder, Orientation Sensor*

1. INTRODUCTION

In general, video monitoring with a camera or detecting object with a range sensor which are installed on the back side of construction heavy equipment have been practiced as a measure for preventing collision accident in Japan. However, in case of video monitoring, it is necessary to conduct the visual judgment with a glance at monitor by operator for confirmation of safety. The operator's physical observation may be the cause the human error in the operating of equipment. In case of range senor, the operator cannot discriminate human from detected object.

In this study, the author developed a detection system that measures distance from heavy equipment to workers using camera image, laser range finder and orientation sensor. This system aims at improvement of detection reliability with use of prevailing sensors.

2. DEVELOPMENT OF WARNING SYSTEM

2.1 DETECTION OF WORKER

There are two main categories in human detection methods with image data directly. The first category is shape-based method and the second category is motion-based method [1]. However, the changing circumstances of camera shooting position with heavy equipment make using the detection methods difficult for the collision warning. Therefore, the author adopted color detection as a stable method of estimating worker in the image data. The workers are required to wear a safety vast that stitched fluorescent tape. If the color of fluorescent tape is detected from the image data, the system determines that a worker is in the camera shooting area.

In order to decide whether a worker who is detected from image data is in the danger zone, 2-D laser range finder and 3-D orientation sensor are used. The 3-D position of worker in the image can be calculated, and issuing of warnings is judged by the results.

2.2 SYSTEM DETAILS

The sensors are installed on the body of heavy equipment, and the installed position is set to the coordinate origin. Figure-1 shows the component of system. The center of camera is set to the X-axis, and the X-Y plane is produced in parallel with the horizon. The X-Z plane is produced in orthogonal with the X-Y plane.

The measured angle of 2-D laser range finder is assigned to the horizontal angle of view. The 2-D laser range finder sends laser beams toward X-Y plane at regular intervals and determines the distance to the objects.

The horizontal angle of view is calculated on the X-Y plane, the angle is determined by camera specification. The horizontal angle can be extended by using wide-angle lens or multiple cameras. The vertical angle of view that can take a contiguous worker is required.

The 3-D orientation sensor is used to measure attitude of heavy equipment which evaluates whether the data of 2-D laser range finder is suitable for detection of worker. On the steep ground, it is difficult to judge what is or isn't the worker from only distance data. Because there is a possibility that laser beams hit ground or upper objects.

In this system, the worker in the dangerous area is determined with the height of measuring point of laser range finder from X-Y plane that is calculated using the converted 3-D coordinate point.

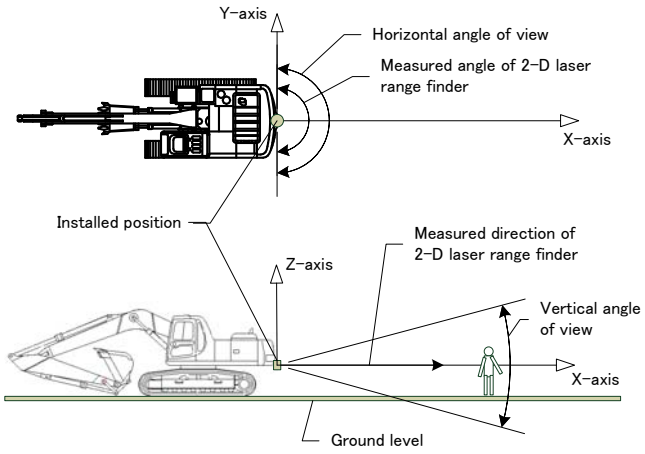

Fig. 1 System component

2.3 EXPERIMENT RESULTS

The author builds a prototype that is shown in Figure-2 with three web-cameras, a 2-D laser ranger finder, and a 3-D orientation sensor. The camera has the capacity to shoot pictures at 640*480 pixels resolution and 60 degree horizontal angle of view. The prototype can take a picture with total 180 degree horizontal angle of view.

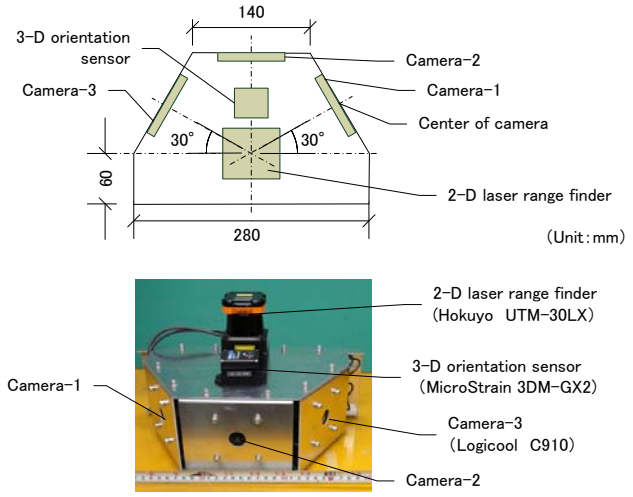

Fig. 2 Configuration of prototype

The operating system of the prototype was Microsoft XP, and Microsoft Visual Studio 2008 C++ and openCV were used as a software development environment. The image processing method for detection of worker's fluorescent tape split RGB image into a red, green, and blue channel and select the pixels that have same color ranges as fluorescent tape has.

Figer-3 shows a picture and laser range finder data captured from the prototype located at 0.7m height and 3m distance from the worker. The color of fluorescent tape was detected in the measured angle of 93 degree to 100 degree range. In this range, the distance that is measured by 2-D laser range finder was about 3m.

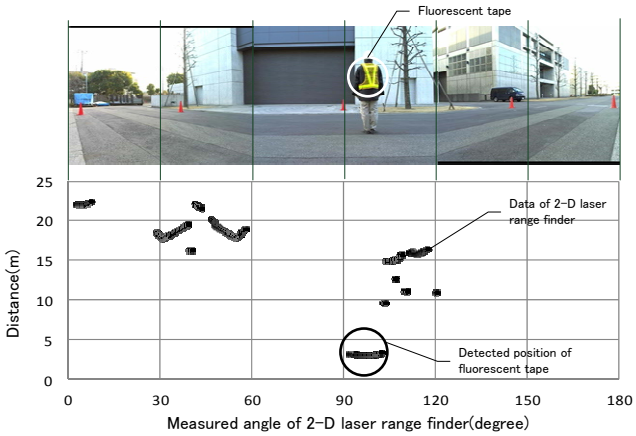

Fig. 3 Measured results of image detection and 2-D lager range finder

3. CONCLUSION

The basic concept of a warning system for preventing collision accident was proposed and the possibility of data processing was verified by a prototype. Improvement of hardware and process connecting alert with measured result are needed to apply this system to actual site.

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