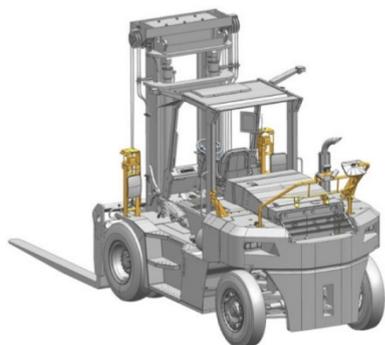


Automatic Human Detection System for Forklifts Watched Over by AI



Mitsubishi Logisnext Co., Ltd.

Big body industrial vehicles such as large capacity forklifts have large blind spots and the forklifts are equipped with safety mirrors and on-board cameras. However, a satisfactory effect cannot be achieved unless the forklift operator pays close attention to these items. The demand for a safe driving support system from customers to Mitsubishi Logisnext Co., Ltd. is increasing year by year, accordingly.

We therefore have developed a technology that uses deep learning to enable real-time automatic human detection from images generated by the cameras on board the forklift, and then commercially release such system as alerting users by such technology. The configuration and features of such system for forklift are presented in this report (**Figure 1**).

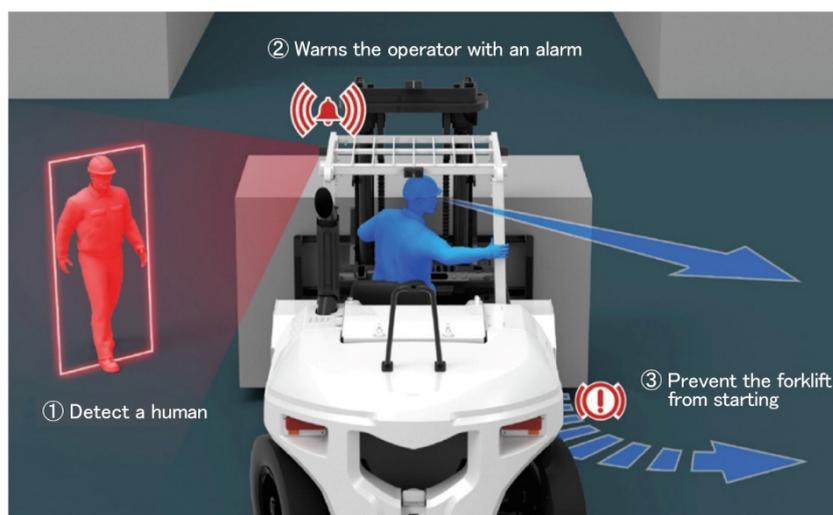


Figure 1 Human detection system

1. Product summary

1.1 Configuration

The system is comprised of cameras that produce images, a controller that detects only humans in the acquired images, and a buzzer and lamp unit to alert the operator at the time of detection. The system configuration diagram is shown in **Figure 2**.

a) Cameras

The on-board cameras are of two types: short-range and long-range. The short-range cameras are used to monitor all around the forklift when it starts off or it is operating at low speed, while the long-range cameras monitor the direction of travel when the forklift is operating at high speed.

b) Controller

The controller uses deep learning to only detect the presence of humans around the

forklift in images from the cameras in real time. When detected, a signal is transmitted to the buzzer and the lamp unit. While receiving the forklift's controller area network (CAN) signals, it controls the on/off state of the detection system and automatically selects which camera images to be monitored.

c) Buzzer

Once detected, the buzzer alerts the operator of the presence of a human. As the alarm volume can be changed, the operator can set the sound at a level appropriate under a given work environment.

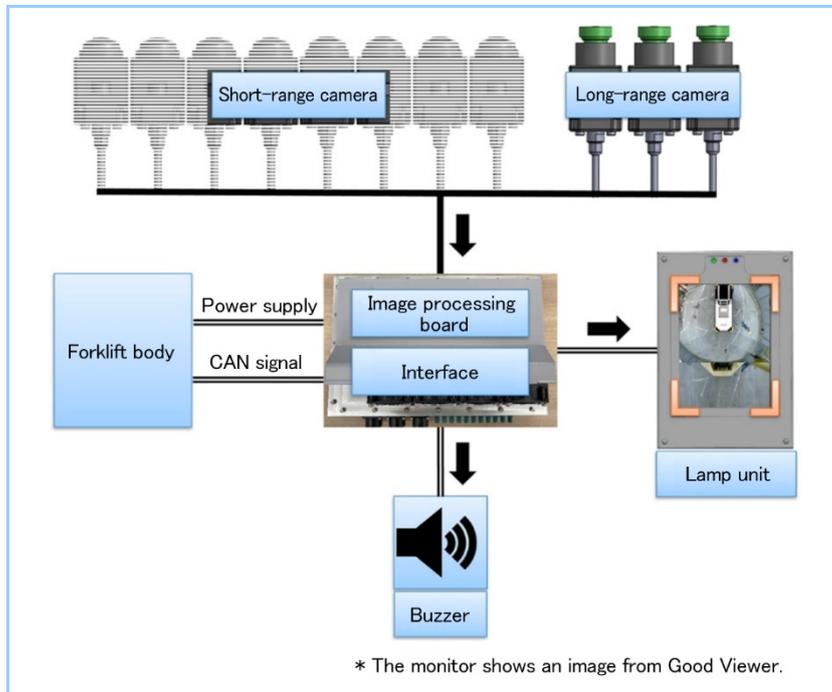


Figure 2 System configuration diagram

d) Lamp unit

The lamp unit indicates to the operator the direction in which the detected human is located. Once alerted by the buzzer, the operator can check the lamp unit to see the human's location that is indicated by one of the four divided areas around the forklift. As the lamp unit is also equipped with a system operation status indicator lamp, it is possible for the operator to check for the occurrence of system errors and other abnormalities. The lamp unit is shown in

Figure 3.

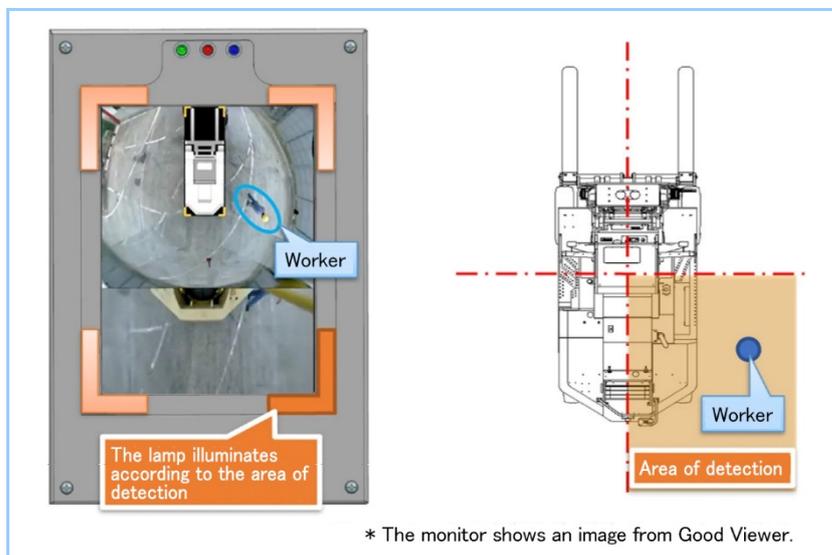


Figure 3 Lamp unit

1.2 Environment resistance performance

This system features high reliability by heat radiation structure to avoid overheat of internal processor, vibration resistance and electromagnetic compatibility, etc., while it has waterproof and dustproof performance, and it is designed so that it may normally operate even in severe working environment of forklift.

1.3 Applicable vehicles

This system is applicable to large capacity forklifts (FD120 to 230-6, FD240-5 and FD310-5) and reach stackers (MR4531-3).

2. Features

2.1 Selective detection of humans

This system employs a Single Shot Multibox Detector (SSD) as a deep learning model to only detect humans in images. With its capability of learning a large number of real environment images collected through field tests and, detecting humans by tuning technology originally developed, it has succeeded in dramatically improving the detection rate (i.e., the rate of detecting a human as a human) while suppressing false detection.

The selective detection of humans allows no false alarm to be issued against objects present in a work environment in which there are usually various items and goods in the vicinity. Therefore, too many warnings can be avoided.

2.2 Automatic camera switching between short-range and long-range

Switching between short-range and long-range cameras is automatically done depending on the speed of the forklift. This enables the monitoring area to be appropriately set while lessening the burden on the operator.

2.3 Detection notification

Once detected, the buzzer sounds to alert the operator of the presence of a human in the vicinity. At the same time, the lamp also illuminates to indicate the direction in which the detected human is located, thus urging the operator to confirm the safety with his or her own eyes and/or on the Good Viewer(*) screen. (*Good Viewer is a support system to confirm the safety through a bird's-eye view of the forklift's surroundings.)

2.4 Prevention of forklift starting at the time of detection

When the presence of a human is detected while a forklift is halted, the system blocks the vehicle from starting to prevent an accident. If this precautionary measure interferes with work progress, it can be switched off temporarily. This feature is realized by a system that is integrated with vehicle control, and is therefore a selling point that our product is different from similar ones of other companies because the latter are sold separately from the vehicle itself and do not have such capability by itself.

3. Future development

The human detection system for forklifts is a safe operation support system that considerably contributes to improving the safety of large forklifts with large blind spots. We will continue to satisfy the needs of our customers for safety by further expanding its application to small forklifts.