3D distance imaging

Contents

Sensors that measure the shape of objects and distance without contact are widely used. There are two types of distance measurement methods: a type that measures only the distance and another that images distance information. They are used for different purposes. Recently, distance image sensors and cameras that can make 3D images of distance information are drawing attention.

This document describes the 3D distance image measurement method and application examples of Hamamatsu distance image sensors that support 3D distance image measurement.

Distance measurement methods

<Distance measurement>

- Ultrasonic method
- Millimeter wave method
- TOF method

<Distance image measurement>

- Stereo method
- Structured light method
- TOF method

Distance image measurement methods

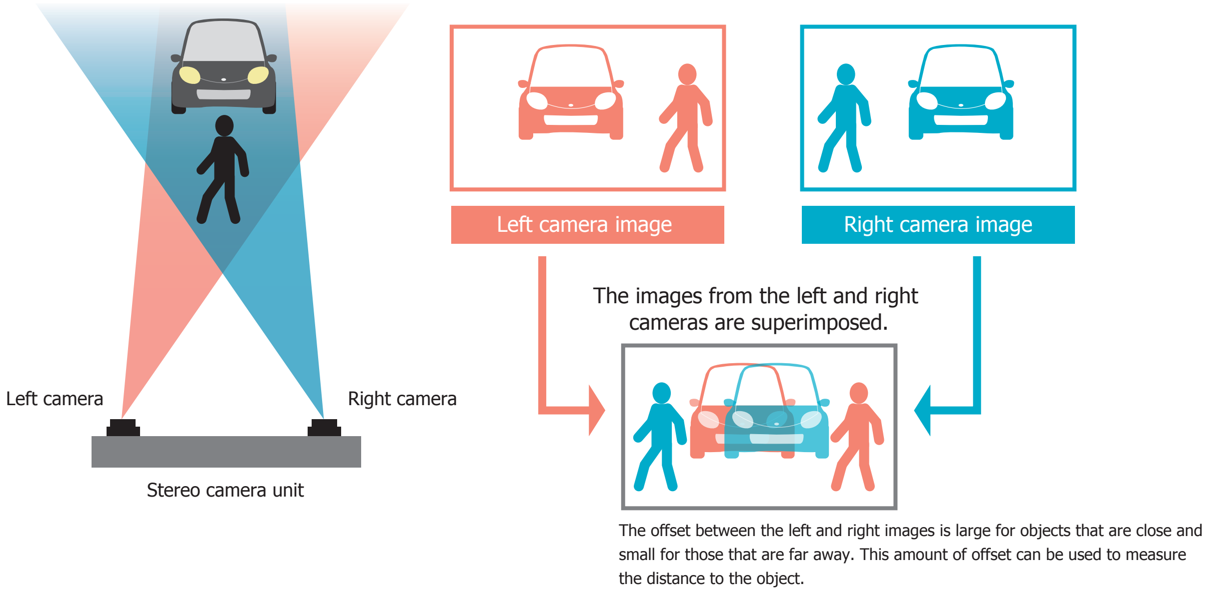
The typical measurement methods for distance images include the stereo method, structured light method, and TOF method. Each measurement method is indicated below.

Distance image measurement methods

Parameter	Stereo method	Structured light method	TOF method
Distance accuracy	Millimeter to centimeter		
Measurement distance range	Short distance to long distance	Short distance	Short distance to long distance
Calculation load	High	High	Low
Use in darkness	No	Yes	Yes
Measurable target objects	Limitation to shape	No limitation to shape	No limitation to shape

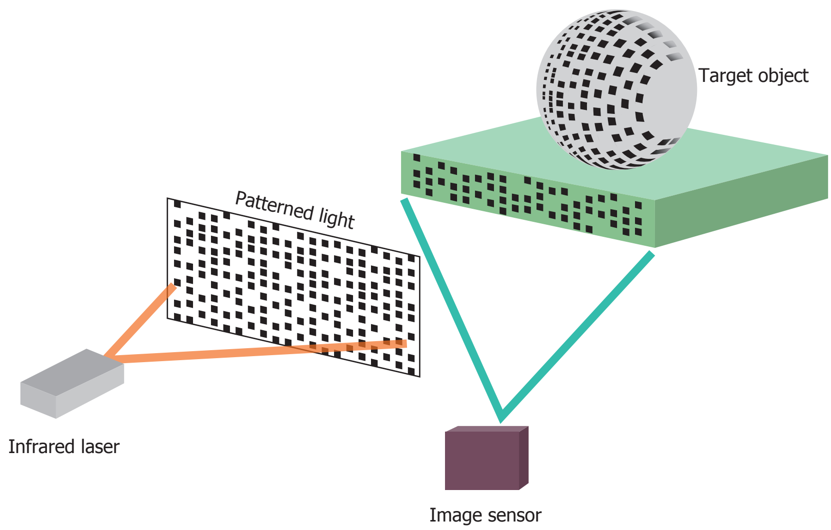
Stereo method

Images are taken by two cameras (left and right), and parallax data is generated. From the data, the distance from the camera to the surface of the target object is measured.



Structured light method

Patterned light from an infrared laser is projected onto the target object, and the image produced is captured by the image sensor. Distance image information is obtained by triangulation.



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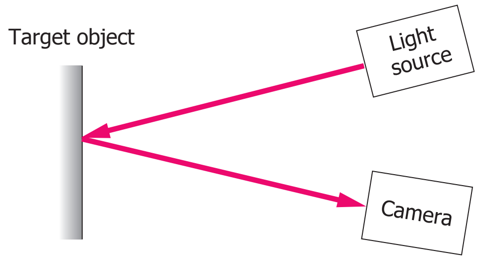
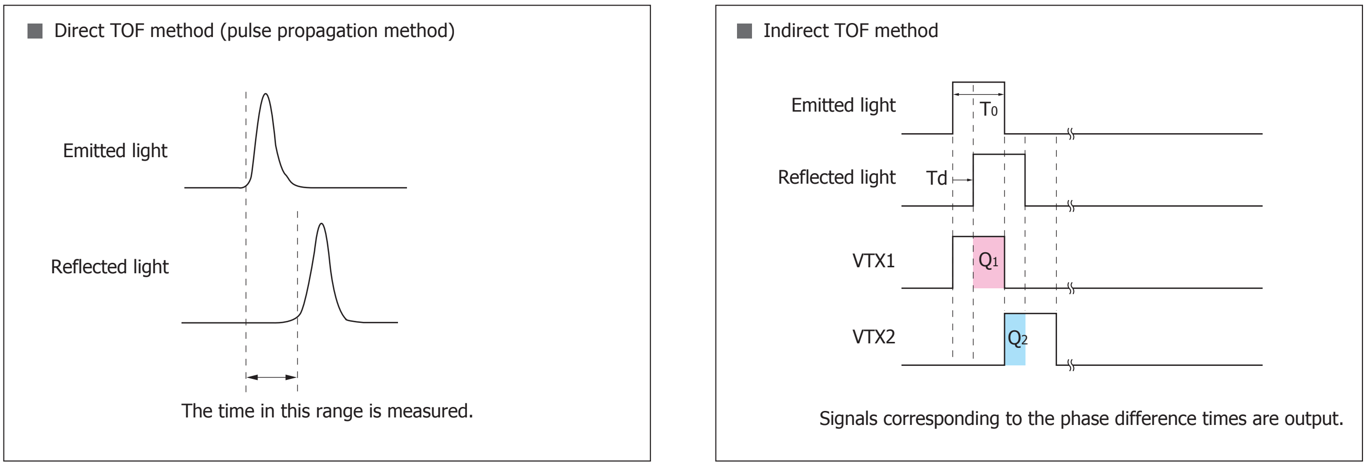
Time-of-flight (TOF) method

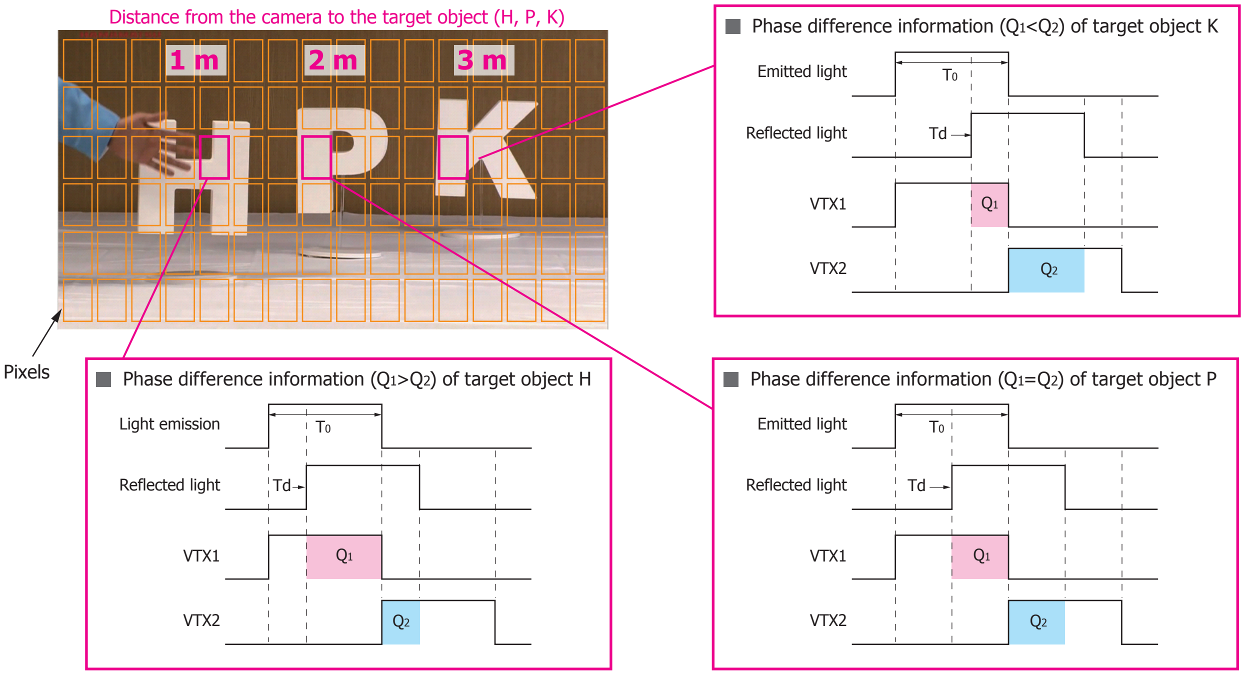
The distance to the target object is measured by directing light onto the object and then measuring the time required for the light to reflect and return. There are two TOF methods. One is the direct TOF method (pulse propagation method) in which the distance is calculated from the time it takes for the light pulse from the light source to reflect from the target object and return. The other is the indirect TOF method in which the distance is calculated from the phase difference information between the emitted light and received light. Hamamatsu distance image sensors use the indirect TOF method.





Indirect TOF method

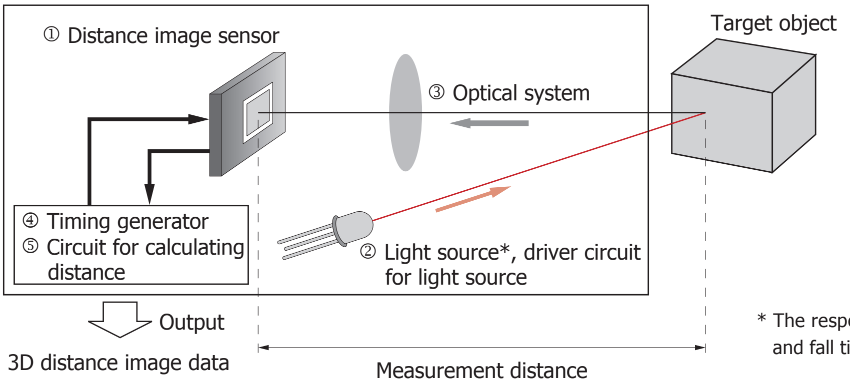
Distance measurement using the indirect TOF method uses the phase difference of light. Distance information is obtained by calculating phase difference signal of each pixel. Because the speed of light is 3×10^8 m/s and light travels 30 cm in 1 ns, phase difference time of 1 ns in the indirect TOF method for the light to make a round trip corresponds to a distance of 15 cm. For example, to measure up to 4.5 m, the pulse widths of the charge transfer clocks (VTX1, VTX2) and the light emission pulse width must be set to 30 ns.



● Configuration example

The following figure shows a configuration example of a distance measurement system using the distance image sensor. The system consists of the distance image sensor, light source and its driver circuit, light emitting/receiving optical system, timing generator, and circuit for calculating distance.

Configuration example of a distance measurement system



* The responsiveness needs to be around 10 ns or less for rise and fall times.

The following is a 3D distance image of three target objects placed at different distances and measured using the configuration example shown above.

Imaging examples

■ Image by a visible light camera

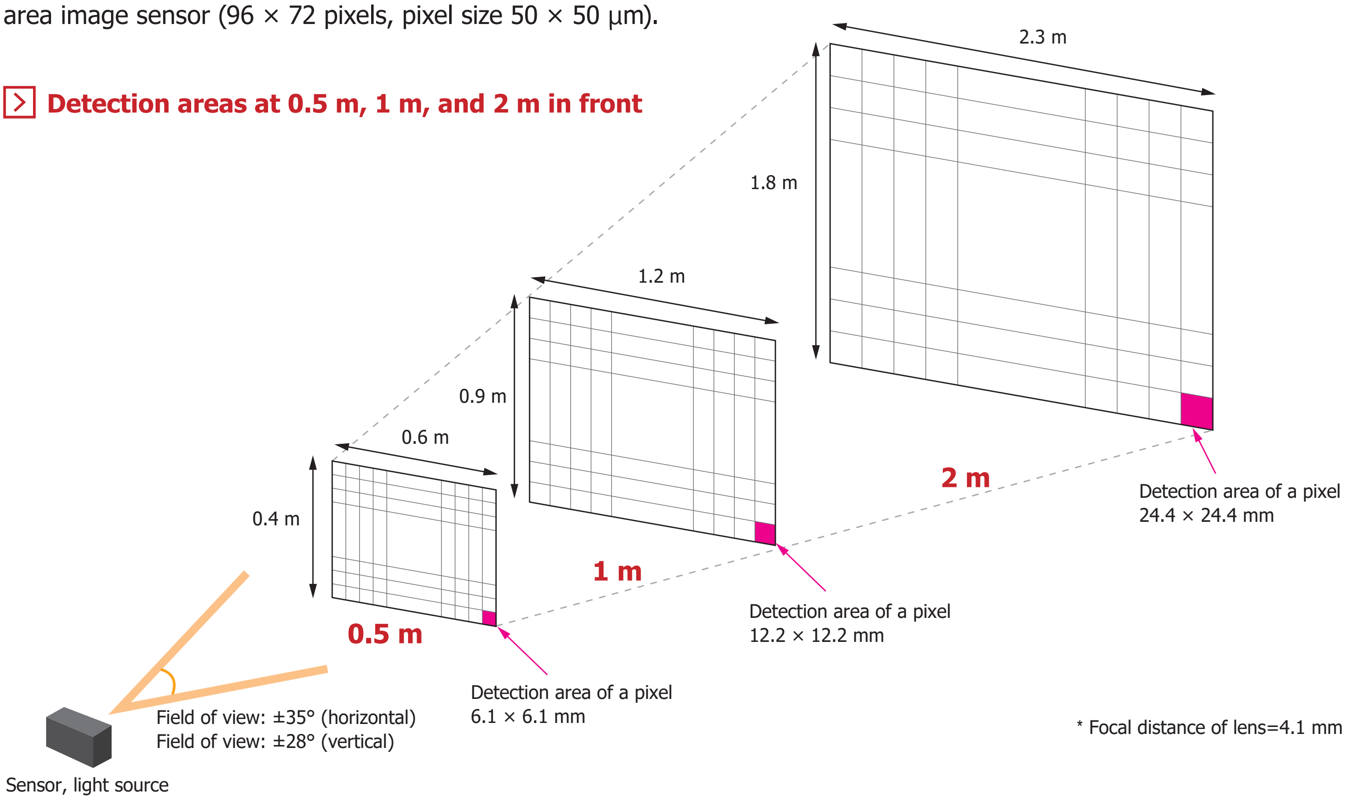
■ 3D distance image using a distance area image sensor

Color representation of distances from the camera to the target objects

Detection area

The following figure shows the detection areas (field of view) at 0.5 m, 1 m, and 2 m in front of the S15454-01WT distance area image sensor (96 × 72 pixels, pixel size 50 × 50 µm).

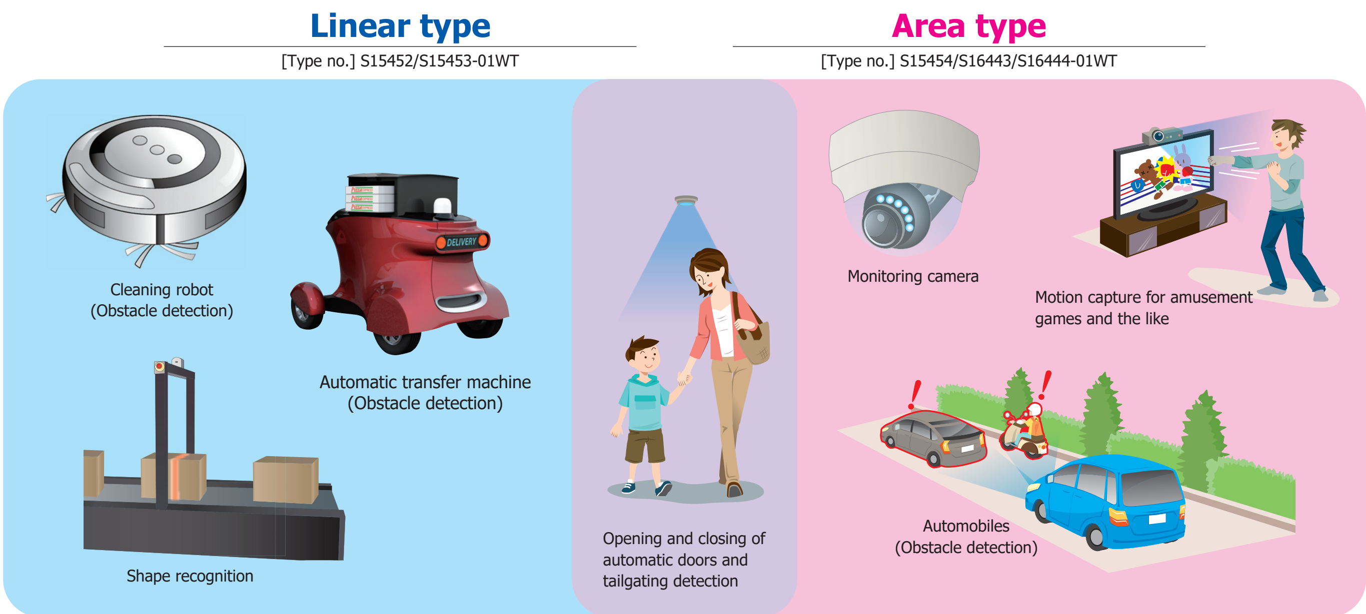
Detection areas at 0.5 m, 1 m, and 2 m in front



* Focal distance of lens=4.1 mm

Application examples

Application examples of distance image sensor are shown below.



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