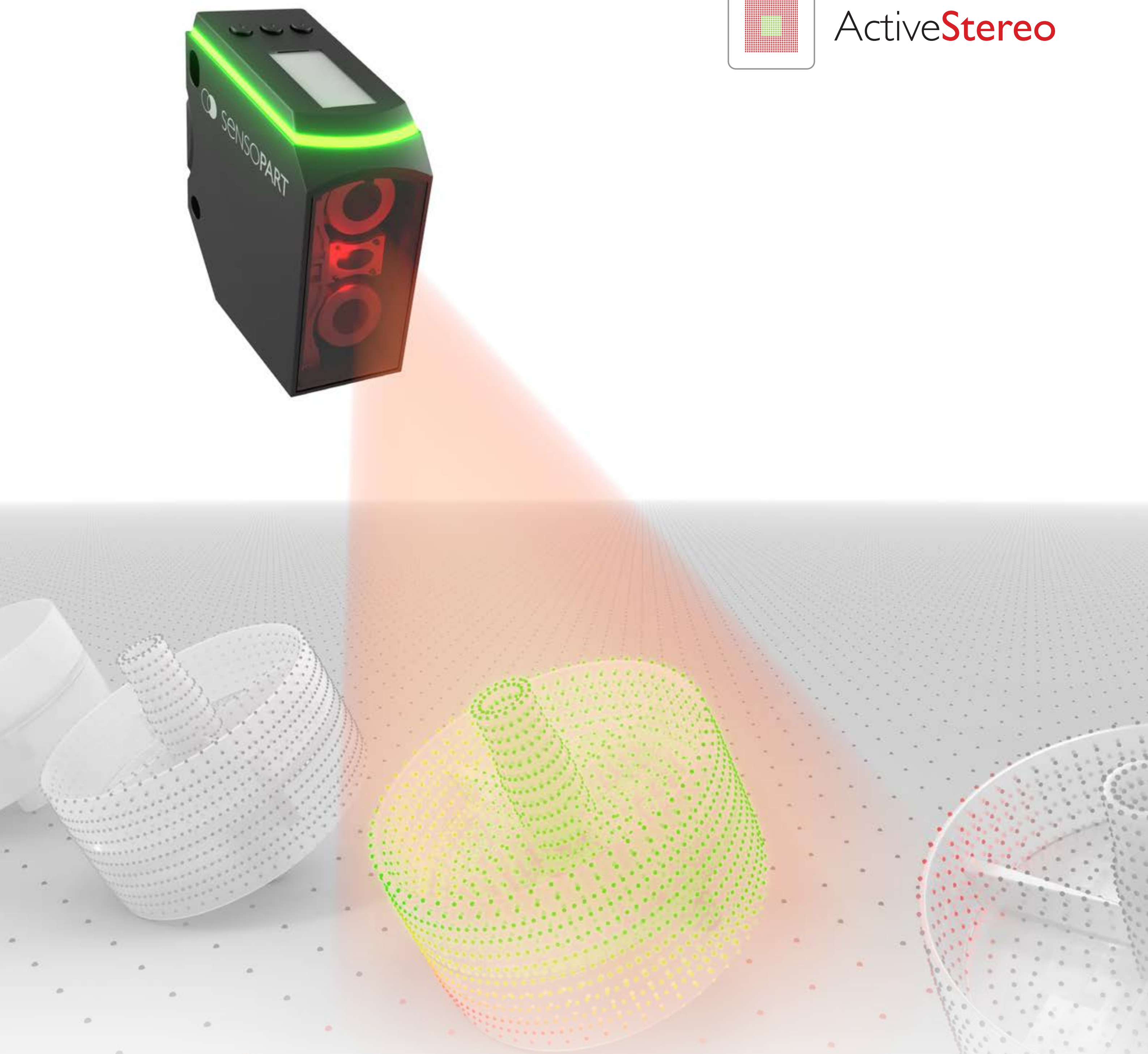
Active Stereo: DTECT® Object 3D

Stereo vision with structured lighting

ActiveStereo



Summary

The **DTECT® Object 3D** combines the **simple operation of classic sensor technology** with the **advanced possibilities provided by image processing**. As a result, even **complex detection tasks** are achieved efficiently with no additional hardware.

Using **surface-related 3D information**, it reliably recognises different geometric features **independently of their color and contrast**.

This means the DTECT® Object 3D defines a **new product segment** that couples improved inspection and detection performance with easy commissioning and delivers uncomplicated access to 3D technology.

Visit *www.sensopart.com* for further information or reach out to your local representative directly.

Initial Situation

The limits of vision

Machine vision and classic optical sensor technology have always focused on different areas of application. Classic sensors are ideal when speed, robustness and easy commissioning are key, but the designs make them less suitable for complex applications. Vision sensors offer a high degree of flexibility and facilitate detailed evaluations, yet require more effort for setup and integrate. Camera systems go a step further and can master highly complex applications.

The DTECT® Object 3D **combines the advantages of these product categories**: It incorporates the simple handling like classic sensor technology as well as the advanced possibilities provided by image processing. Like a switching sensor, it distinguishes between two states, and these can be defined directly on the sensor using either the simple teach-in process or via the IO-Link digital interface – even when it is installed.

A further key aspect of the DTECT® Object 3D is the data basis with which it operates. Instead of the contrast-based image processing typical for 2D cameras or the height/energy information at selected points based on trigonometry or time-of-flight used in classical sensor technology, the DTECT® Object 3D uses **3D information.** This creates a completely new performance profile: **a high level of inspection and detection performance combined with simple operation**.

The DTECT® Object 3D is not merely a further refinement of existing products – it defines an entirely **new product segment**. At SensoPart, we are pleased that we can now offer our customers a **new dimension in sensor technology** that employs volume evaluation. Previously unattainable opportunities in 3D technology are now accessible to users and employ the same interaction principles and formats as classic sensor technology.

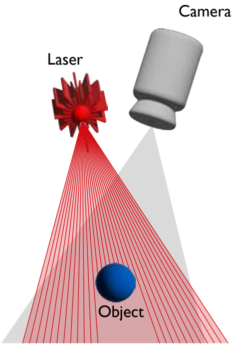
An in-depth view

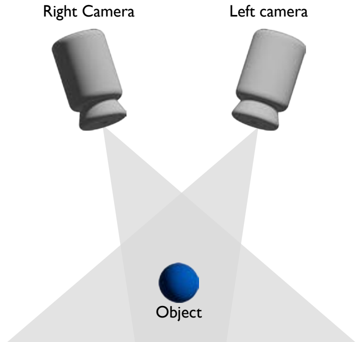
A basic introduction to 3D measurement technology

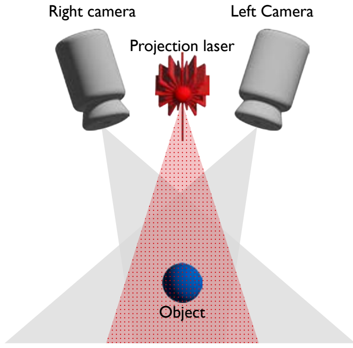
3D technology makes it possible to capture spatial information that goes beyond two-dimensional contrast or brightness values. It provides **geometric data on the shape, position and volume of objects**, thereby establishing a foundation for precise execution of inspection, detection and automation tasks.

Three different methods are generally used in 3D sensor technology. These differ in terms of their measurement principle, the accuracy that can be achieved, and the effort required for integration.

- In the **time-of-flight method (ToF)**, the travel time of emitted light pulses is measured to determine distances. This approach is robust, operates reliably even over long distances, and can be integrated in systems with comparative ease. However, there are limitations when it comes to resolution and accuracy, especially if the structures to be detected are very delicate.
- **Stereo vision** uses two camera images that are captured from perspectives that are slightly offset with respect to each other. When these two images are combined, a three-dimensional model of the scene can be calculated. This method delivers good results, provided the surface of the object has sufficient texture or contrast. However, stereo vision is at its limits when confronted with homogeneous surfaces or in poor illumination conditions.
- The **active stereo** method enhances the approach used in stereo vision by including an additional projection illumination. The sensor generates the contrasts on its own. This means that even low-contrast or uniform surfaces can be reliably detected.







Method	Time-of-flight (ToF)	Stereo vision	Active stereo
Measurement principle	Determine the travel time of the light between the emitter and the object	Compare two camera images captured from offset perspectives	Stereo vision with internal illumination
Advantages	Robust even over greater distances, easy system integration	Good results with high-contrast or structured surfaces	Reliable even with low-contrast or uniform surfaces
Disadvantages	Limited resolution and accuracy with delicate structures	Performance limitations with homogeneous surfaces and poor illumination conditions	Higher system requirements, additional hardware required

DTECT® Object 3D

Why Active Stereo?

While **time-of-flight** proves effective especially with its long ranges, **stereo vision** is powerful for high-contrast structures, and **active stereo** enables reliable results even on challenging surfaces. With the DTECT® Object 3D, SensoPart has developed a sensor that operates dependably and process reliably in widely differing environments without external illumination. This is made possible using the active stereo technology with an internal infrared laser as the light source. No additional hardware, such as illumination, PC or programming, is required. Furthermore, it creates a sharper depth image in comparison to time-of-flight technology, enabling more delicate inspection tasks to be performed. The strength of active stereo in short-range applications is evident, as time-of-flight technology demonstrates its better effectiveness over that of (active) stereo due primarily to its greater scanning distance in relation to the size of the measurement system.

From pixels to a solution

How the DTECT® Object 3D works

The 3D detection of the DTECT® Object 3D is based on **stereo vision with structured illumination**. A **laser pulse** is formed into a defined **light pattern** (point cloud) using an optical element and projected onto the object. The projected pattern is in the **infrared range**, which makes the measurement largely insensitive to ambient light. Two camera chips detect the pattern from offset perspectives and from this reconstruct a **depth image**. The subsequent **height-based detection** provides the basis for qualifying the actual state. A **red laser** illuminates the sensor's field of view during the teach-in process to provide **spatial orientation**.

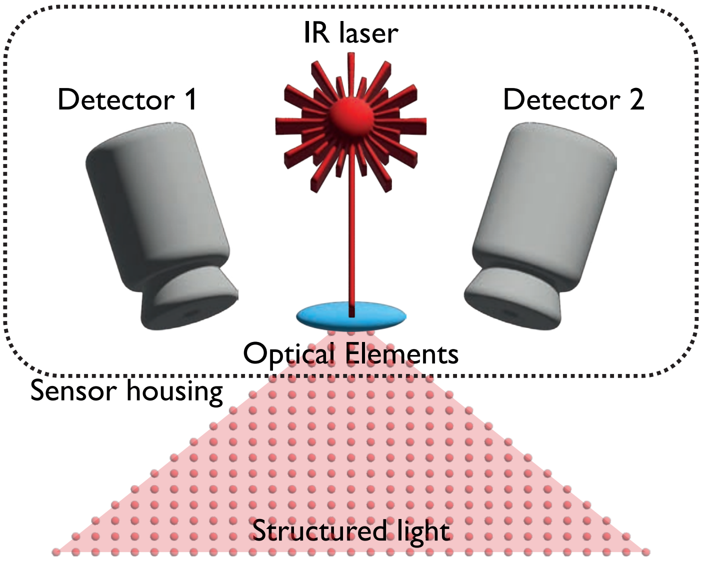


Figure 1: Schematic diagram of the sensor's design

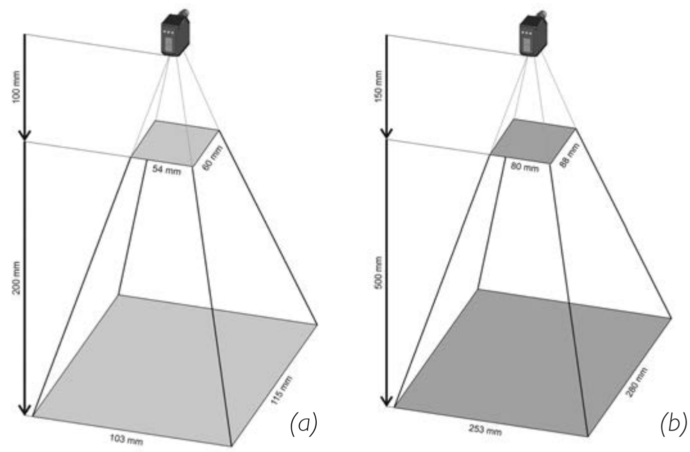


Figure 2: Volume under consideration for the (a) close-proximity version and (b) distance version of the DTECT® Object 3D

The DTECT® Object 3D is based on two hardware platforms resulting from a close-proximity and a distance version. The **close-proximity version** with a **working distance of 100-200 mm** and a field of view in accordance with 2.1 (a) is intended for detecting smaller volume differences. The lower limit when the entire field of view is used is a volume of about 1 cm^3. With the **distance version**, differences down to a lower limit of about 2 cm^3 can be detected at a **working distance of 150-500 mm** in a field of view corresponding to the specifications given in Figure 2.1 (b). However, due to the large number of influencing factors, it is always important to test applications that utilize the range right out to the limits to assess their feasibility.

The DTECT® Object 3D operates using the **snapshot method**, in which one complete image is detected per detection cycle. This also allows reliable assessment of **moving objects** (e.g. on a continuously running conveyor belt). The **scan rate is 100 fps**, and the **response time lies between 26 and 37 ms**. Every cycle includes the image recording, the calculation of the depth image and the resulting definition of the state.

The evaluation compares the **actual state** recorded with the previously taught-in **"OK" or "NOK" references**. Since the DTECT® Object 3D evaluates the **volume distributions**, it operates **independently of color** and is **insensitive to surfaces** over a wide range. The match is reduced to a **binary switching signal**. The **threshold value** used for this is **configurable** and can also be adapted at a later point in time. The geometric approach to observation makes the matching **independent of the absolute position and orientation in the object plane**.

Obtaining a valid decision requires that the object or feature to be evaluated be **fully present within the sensor's field of view**. This boundary condition ensures that the envelope curve is detected in its entirety and that the target/actual comparison can be performed without ambiguity.

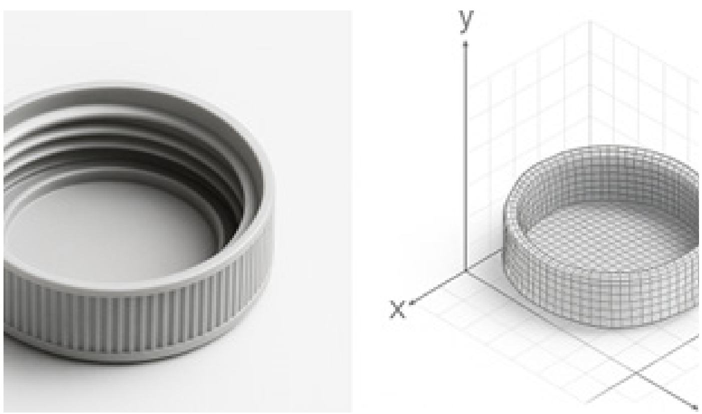
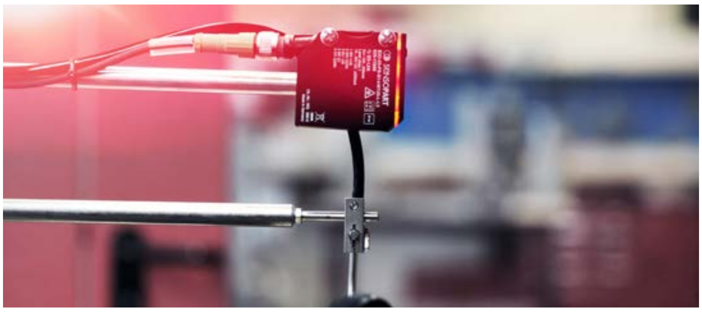


Figure 3: Example object and its volume as viewed by the sensor

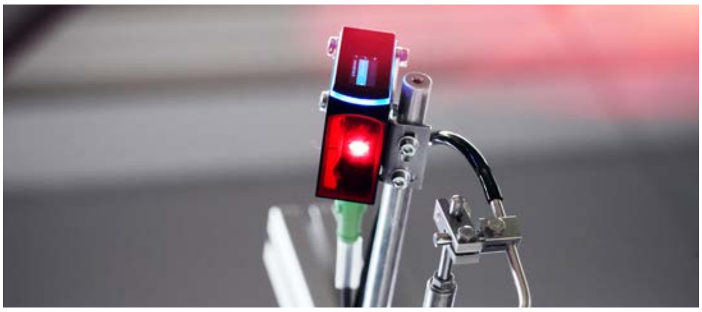
More than technology

What makes the DTECT® Object 3D special

- **Direct integration as with classic sensors**
  Just as with photoelectric sensors, the DTECT® Object 3D provides **a single output signal** (OK/NOK). This means existing systems can be enhanced with no significant adaptations; the integration is performed in the same manner as with customary sensor solutions.



- **3D height information instead of contrast dependency**
  The DTECT® Object 3D operates on the basis of **surface-related 3D data**. This means the measurement result is independent of the **remission of the surface** (color, material). Applications that require **depth information** can be realized reliably even **without external illumination**. At the same time, the projected infrared illumination makes the system **robust against ambient light.**



- **Field of view for flexible feeding**
  The ability to adjust the **field of view** as required enables reliable detection of varying component locations and positions within the detection range. This means **no mechanical adaptations in the feeding** are required, which further simplifies the integration into the overall system. The region of interest (ROI) can be adapted within the field of view to obtain more stable detection and thereby reduce the size of the smallest detectable volume difference.

- **Teach-in requires no previous knowledge**
  Parameter configuration is carried out **easily via IO-Link or a button** directly on the DTECT® Object 3D. **No special software** is needed and **no in-depth technical knowledge** is required. The teach-in process corresponds to the familiar procedure for classical sensors.

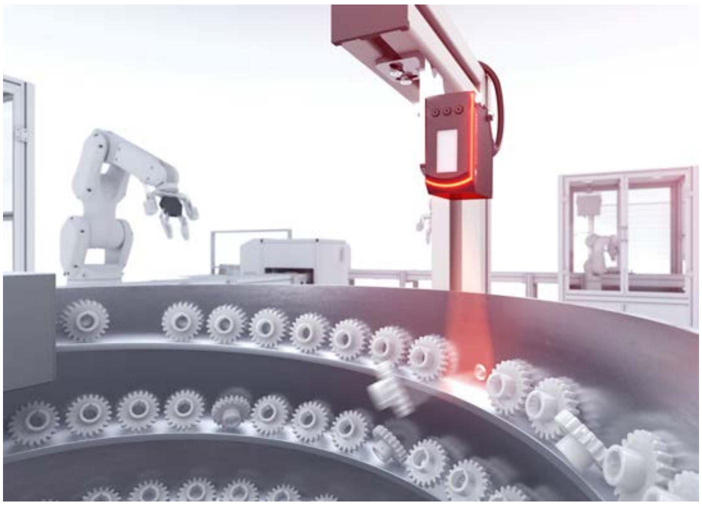
- **Very compact – the smallest 3D device on the market**
  The uniquely **small housing** opens up installation possibilities that are hardly realizable using conventional 3D systems. This reduces the engineering effort required and simplifies use in existing machine layouts.

Practice check

Where the DTECT® Object 3D makes all the difference

1) **Completeness check of assemblies or individual features**
The DTECT® Object 3D evaluates the geometry of the surface and recognizes missing components or those that have been mounted twice based on the 3D height information. Unlike contrast-based methods, the evaluation is **independent of color and material** and also works on shiny or non-textured surfaces. The **snapshot principle** enables inspection during operation – without stopping the cycle. In summary: robust completeness monitoring independently of color and sheen, short cycle times, simple OK/NOK results output for direct PLC integration.

2) **Orientation check (prone/supine position), even without isolation**
In vibratory conveyors or on conveyor belts, the DTECT® Object 3D reliably evaluates the orientation of parts (e.g. concave vs. convex) by evaluating the **volume distribution** based on the depth map. Thanks to **surface-related 3D data**, no isolation is required. With stable feeding, the ROI can be reduced to the size of a single part, which eliminates the need for isolation. In summary: reliable position/orientation detection without isolation, less mechanical equipment and lower conveyor complexity, stable results even with varying surfaces.



3) **Completeness or empty check of small boxes, trays, and conveyor lines**
The DTECT® Object 3D recognizes whether a container is empty or occupied by comparing the **target volume** with the **actual volume**. This also works with dark or patterned parts, provided that they are larger than the area shaded by the side walls in the container. The **integrated IR structured illumination** reduces the influence of ambient light. No external illumination is required. The **flexible field of view** and the **small physical shape** factor simplify retrofitting di-rectly above the conveyor line. Often, mechanical adaptations are superfluous. The **configurable threshold** permits rapid adaptation to new shapes. In summary: empty checks independent of contrast, easy integration thanks to input/output signal (OK/NOK) and and high process reliability during operation.

Summary

See depth, create added value

The **DTECT® Object 3D** combines the **performance of surface-related 3D-Data** with the **simple operation of a sensor**. Thanks to **stereo vision with structured IR illumination** and **snapshot recording**, it operates independently of contrast and color with **no external illumination**. Moreover, the sensor delivers **reliable, stable results even when subject to ambient light**. At **100 fps**, it is also suitable for **inline inspections**. The DTECT® Object 3D is **very compact** and has an **OK/NOK output** as well as a **teach-in function via IO-Link or a button**. The flexible ROI simplifies integration. Thanks to its innovative technology, the DTECT® Object 3D offers an optimal solution for demanding applications, such as completeness monitoring, precise position detection without isolation as well as reliable empty checks.

Visit *www.sensopart.com* for further information or reach out to your local representative directly.

DTECT® Object 3D – Product overview

Sensor	Light type	Adjustment	Working range	Special features	Additional information
DO3D-10-CH-S1-LI-W135-L-L5 626-11000	IR laser (operation) Red light (teach-in)	Teach-in via button, IO-Link	100 ... 200 mm	Laser class 1	
DO3D-10-CH-S1-LI-W230-L-L5 626-11001	IR laser (operation) Red light (teach-in)	Teach-in via button, IO-Link	150 ... 500 mm	Laser class 1	

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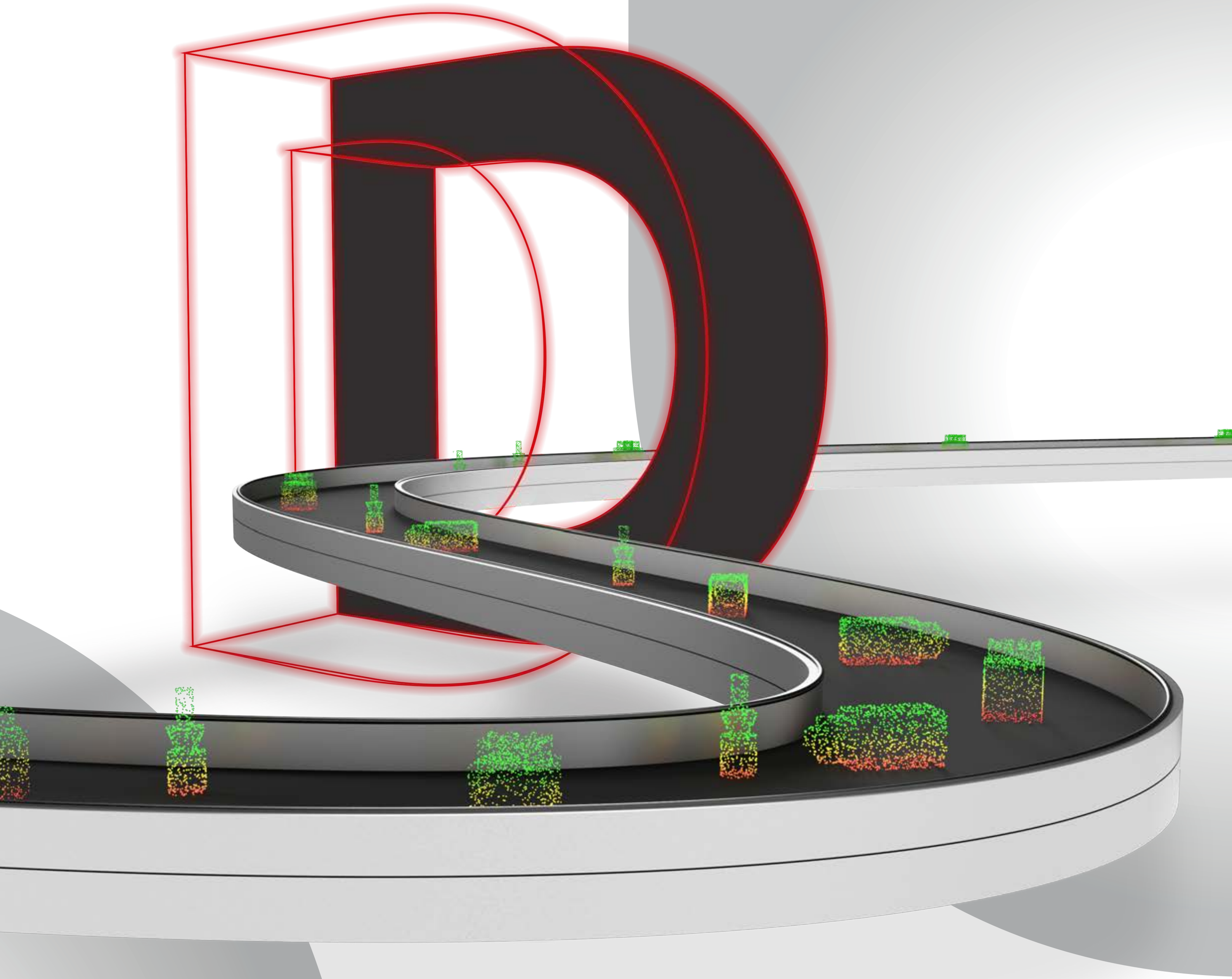

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DTECT THE DIFFERENCE

DTECT® Object 3D

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SensoPart worldwide

With our global network and worldwide subsidiaries, we are always ready to support you.

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