SICK AG WHITEPAPER

SELECT THE BEST TECHNOLOGY FOR YOUR VISION APPLICATION

AUTHORS

Fredrik Nilsson
Manager, Product Unit 3D Vision, SICK AG
Anders Murhed
Manager, OEM Business Team, SICK AG

SUMMARY

This white paper describes differences and benefits of 2D and 3D Vision technologies respectively, and how these can be applied to successfully solve various machine vision tasks.

SICK
Sensor Intelligence.

Table of contents

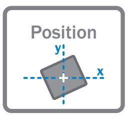
Vision Introduction

Machine vision technology gives machines the gift of sight, replacing or complementing manual inspection tasks by using digital cameras and image processing. This technology is used in a variety of industries to automate production and improve product quality. Machine Vision applications range from fairly basic tasks, like presence detection, to complex real-time inspection and grading tasks in harsh environments.

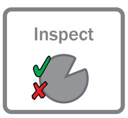
Most vision systems use peripheral equipment to perform their tasks, such as a photoelectric switch for image triggering, a mechanism to reject faulty objects, and a touch-panel operator interface for monitoring and control. Hence the term “vision system”.

Machine Vision tasks can be categorized into one of four main tasks. In many cases, a vision system for a certain application consists of a combination of several such tasks.

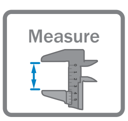
Vision tasks



Positioning is the task of detecting and locating objects, then report presence or coordinates of the object.



Inspection is the task of verifying product quality, e.g. check presence of all parts of an assembly or find defects and deviations.



Measurement is the task of determining object dimensions such as length, width, height, area and volume.

Reading is the ability to decode and read texts, such as 1D code, 2D code and OCV/ OCR.

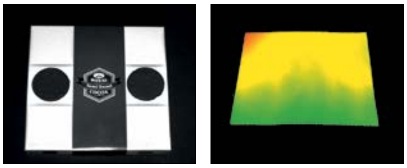
No matter what application you need to address, SICK can provide the appropriate vision technology for you. Every application needs to be solved using the appropriate technology. Therefore, it is good to understand which technologies are available and which strengths they have in different contexts. This white paper gives an overview of suitable machine vision technologies for solving a range of different tasks and applications.

Solving applications in 2D or 3D

There are often many possible ways to solve a specific vision task. In some cases, the choice of either 2D or 3D vision is obvious, but in other cases both technologies could work but each provide certain benefits. It is important to understand these benefits and how this applies to a given application in order to provide a reliable machine vision solution.

2D vision

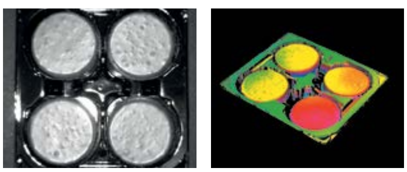
2D is particularly useful for applications with high contrast, or when the texture or color of the object is the key to the solution. 2D is used to solve all four vision tasks and is the dominant technology for machine vision solutions.



The printing on the box will be visible using 2D (left picture), with 3D vision only the shape of the box is checked.

3D vision

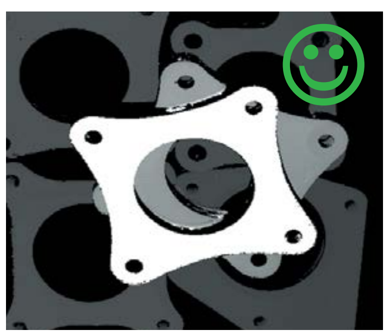
3D is suitable for analyzing volume, shape or 3D position of objects, but also for detection of parts and defects that are low contrast, but have a detectable height difference. 3D is mainly used for measuring, inspection and positioning, but there are also cases where 3D is used to read imprinted code or text when contrast information is missing.



Even very slight height differences will be shown with 3D vision (right picture), the variation is hardly noticeable using 2D (left picture).

2D and 3D application examples

2D image



3D image

3D application example

The task is to find the next object on top to be picked by a robot.

Due to the low contrast conditions in the 2D image the top object is hardly recognizable. In the 3D image, the object on top can easily be found because the closest object appears as the brightest in the image.

2D image

3D image

2D application example

The task here is to verify the print on the package.

A 3D image only shows contour and the shape of an object. Labels and print are not visible in the image. The print on the package can therefore only be verified in a 2D image with good contrast.

2D technologies

In 2D imaging, the scene to be analyzed is captured either instantly by an area camera or by a scanning method using a line scan camera. In both cases, the final representation of the scene is an image of either intensity values (monochrome image) or color images (often RGB values). The key elements for capturing an appropriate 2D image for the task are, besides the sensor imager itself, the choice of lens and illumination.

2D illumination

The success of a 2D application depends on the image quality, which in turn depends on selecting a good lighting method. Correct lighting emphasizes the features to analyze, ensures high image quality and enables consistent appearance of features over time, regardless of ambient light.

In machine vision there are several terms which describe light:

- Illumination is the way an object is lit up.
- Lighting is the actual lamp that generates the illumination.
- Ambient light is indirect surrounding light, such as sunshine coming through the window.

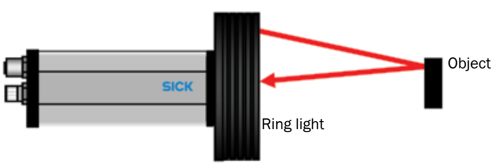
Understanding some basic illumination principles will assist in selecting of the right kind of lighting for your application:

- Matte surfaces can be illuminated by direct light.
- Glossy surfaces require diffuse, indirect light to avoid reflections.

Important lighting types

- Ring light

A ring light is mounted around the optical axis of the lens, either on the camera or somewhere in between the camera and the object. This type of lighting is direct, and thus more suitable for matte surfaces.

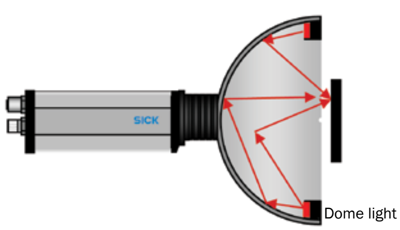


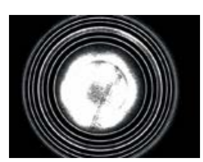
Without ring light, less contrast.

With ring light, more contrast, note the glare on the glossy center surface of the disc.

- Dome light

Dome light produces indirect light with uniform light intensity by reflecting the light off of a dome mounted around the optical axis of the lens. This type of lighting minimizes reflections on the object and is suitable for glossy surfaces such as reading the date on packaging that would cause glares and unwanted reflections under direct lighting.





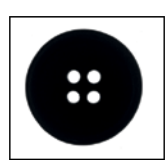
Glares on a metallic surface.

No glares, revealing print on a metallic surface.

- Backlight

Using a backlight design the object is illuminated from behind to produce a contour or silhouette. Backlight is very useful for measuring and positioning tasks, where a precise silhouette is important and contrast features on the object itself could interfere with the task.

Regular light.



Backlight produces a silhuoutte.

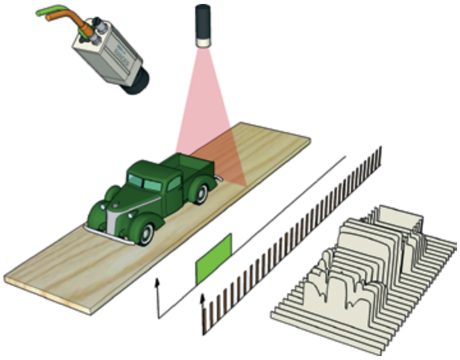
3D imaging technologies

Catching the third dimension can be done in many different ways. Different machine vision technologies are available, each of which has its pros and cons. 3D imaging technologies used by SICK can be divided into two categories:

- Scanning technologies
- Snapshot technologies

In a scanning technology, 3D images are acquired profile by profile by either moving the object through the measurement region or by moving the camera over the object. To obtain the correct 3D data and thus a valid 3D image, the movement must be either constant or well-known, e.g., by using an encoder to track motion. The created 3D images are usually very accurate.

Snapshot technologies create a complete 3D image of objects by taking a single shot just like a typical consumer camera, but in 3D. Object or camera movement is not necessary, but the technologies produce images that are not as accurate as scanning technologies. The 3D imaging technologies described in this document are laser triangulation (scanning), time-of-flight (snapshot) and stereo (snapshot).



Laser triangulation
Laser triangulation uses a laser line and a camera to collect height profiles across the object. The profiles are put together to create a 3D image while the object is moving. Since the height profile acquisition requires object movement, the method is referred to as a scanning technology. Laser triangulation has higher measurement accuracy than time-of-flight but it has a more limited measurement range.

Time-of-flight
Time-of-flight (TOF) 3D cameras creates 3D images by using snapshots. This means no object or camera movement is needed. The technology measures the time-of-flight of a light signal between the device and the target for each point of the image. By knowing the phase shift of the signal time arrival relatively to the initial signal, the distance between the device and target can be derived. The result is an instant 3D image of the target. Time-of-flight is well suited for applications with a large field-of-view and working distance over 0.5 m.

First step: Illuminate the target by a light pulse from the camera.

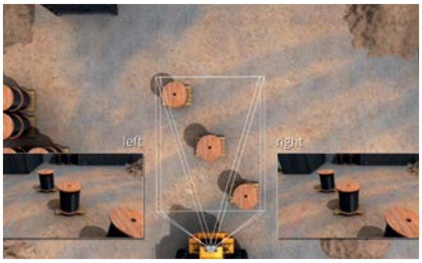
Second step: Measure the time for the light to get back to the camera.

Third step: Create a depth map.

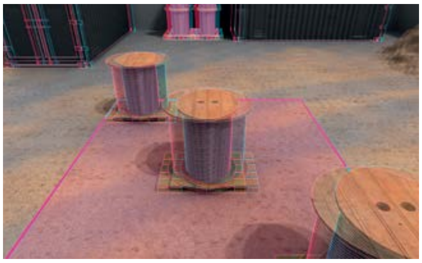
8018982/2015-11-09

Stereo

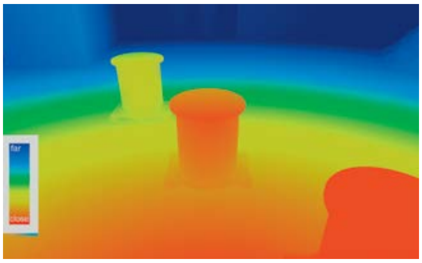
Stereo imaging works similar to human vision and provides snapshot 3D images without the need for external movement. It combines two 2D images taken from different positions and finds correlations between the images to create a depth image. Unlike laser triangulation and TOF, stereo technology does not depend on a dedicated light source. However, to find correlations the two images need to have sufficient details and the objects sufficient texture or non-uniformity. It is hence suitable for applications with a large field of view and for outdoor usage. To obtain better results, one may need to add those details by illuminating the scene with structured lighting.



First step: Take two images from different positions.



Second step: Find correlation between the images.



Third step: Create depth image.

3D technology comparison

In conclusion there are several methods to achieve 3D imaging, selecting one depends on which would be the most appropriate for a given application and its environment. Key features of each 3D technology are summarized below.

Laser triangulation

- Light source: line projection laser
- No need for ambient light
- High detail resolution and accuracy
- Relatively short measurement range
- Occlusion possible where the camera cannot see the laser when it is hidden behind an object
- Scanning technology

Time-of-flight (TOF)

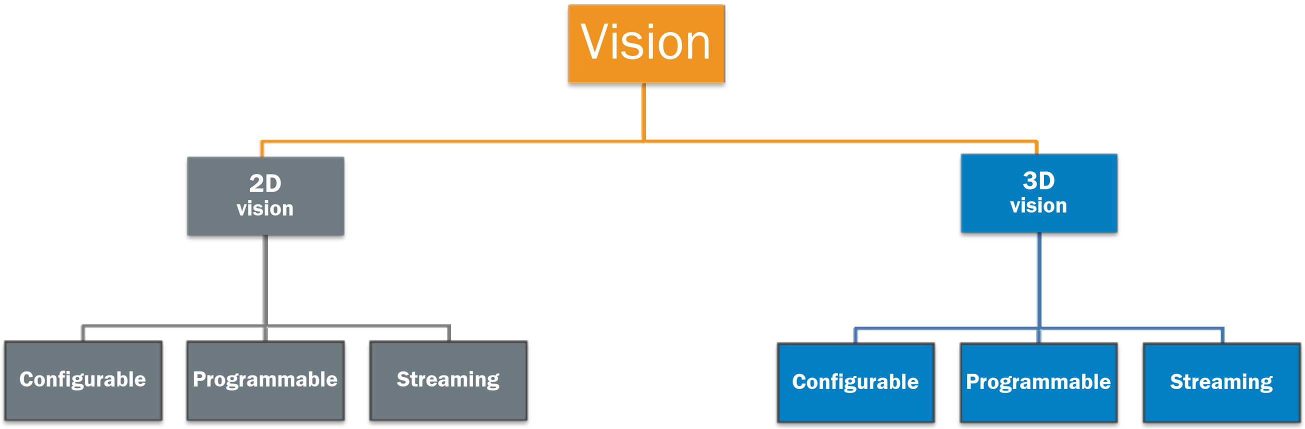
- Light source: time modulated
- No need for ambient light
- Large measurement range
- Relatively low detail resolution and accuracy
- Snapshot technology

Stereo

- Light source: passive ambient light
- Relatively low detail resolution and accuracy
- Large measurement range
- Suitable for outdoor applications
- Snapshot technology

Vision portfolio

SICK has a wide Vision portfolio, from easy to configure to the most flexible and powerful data streamer, for both 2D and 3D.



The setup of a vision system varies widely in complexity, and can involve anything from a quick installation by an inexperienced user to a large project with advanced algorithm development and programming. We have segmented our vision portfolio into three main categories in order to support you regardless of your experience or the complexity of your task.

Configurable

The simplest vision systems are self-contained cameras with built-in image triggering, lighting and embedded image analysis capabilities. Their configuration is simple and can be performed by any technically oriented person after a few hours of training.

- Easy-to-use vision sensor
- Stand-alone operation
- Parameter configurable
- Result output
- Intuitive GUI for easy configuration
- Rapid solution development
- Remote configuration via PC
- SOPAS
- Embedded image processing

Programmable

These cameras are in the mid-range of complexity. Like the configurable ones, the analysis is embedded in the device. The difference is that they are more flexible in hardware configuration and software programming. A few days of training are needed to become an application developer.

- Flexible vision camera
- Stand-alone operation
- Versatile user programming
- Result output
- Flexibility using tailor-made GUI
- Flexible solution development
- Remote configuration via PC
- AppSpace, IVC studio
- Embedded image processing

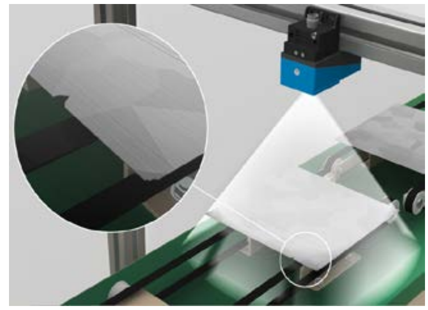
Streaming

The most flexible vision systems are PC-based. The cameras generate images while the analysis is performed on a PC. Expert application developers often prefer this type of system, since it allows full flexibility to create both customized system functionality and algorithms in demanding applications.

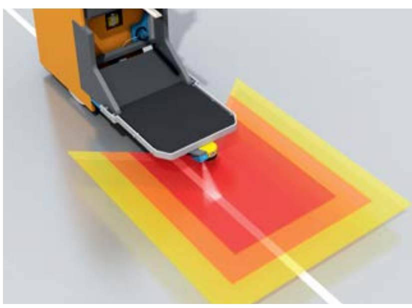
- Data streaming camera
- External PC processing
- Versatile image acquisition
- 2D and 3D image data output
- Flexibility by development GUI
- Fully flexible solution development
- Remote configuration via PC
- Software development kit
- PC image processing

Typical 2D applications

Date code inspection
Checking print quality on paper is a typical 2D task. Various light and filter methods can be used to improve the contrast.



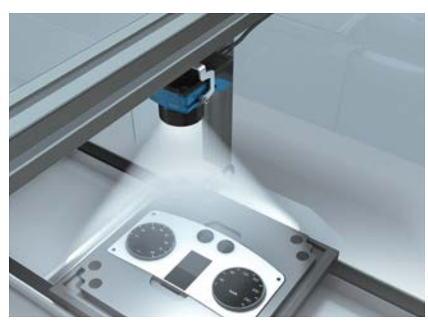
Dimensional verification
Shape inspection of flat objects is commonly solved by using 2D. Backlight illumination can be used to enhance the object's silhouette.



AGV line guidance
Tracking of lines and symbols painted on the floor is a flexible and simple way to automatically guide AGV:s.

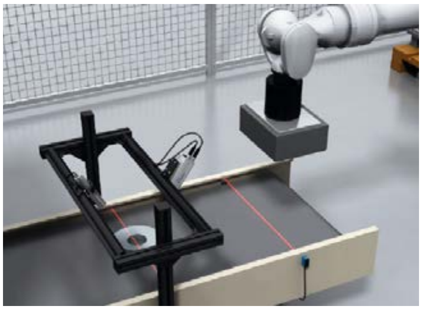
Type verification by color
Color 2D inspection is an efficient and reliable way to sort or verify the product type when capsules or labels differ in color.

Inline stain detection
Stains and contamination can be detected with 2D color or greyscale cameras. Different filter and lighting methods can be used to highlight the stain.

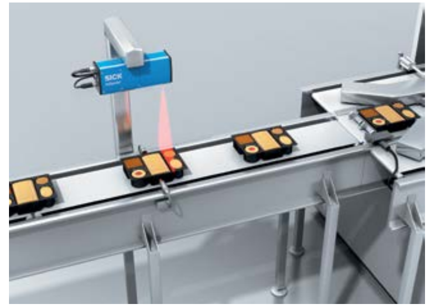


Assembly verification
Part assembly of contrasting components is easily inspected using 2D. Good tool selection enables reliable nspection.

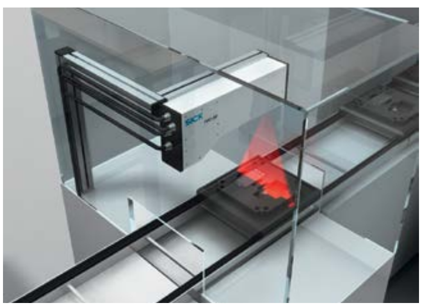
Typical 3D applications



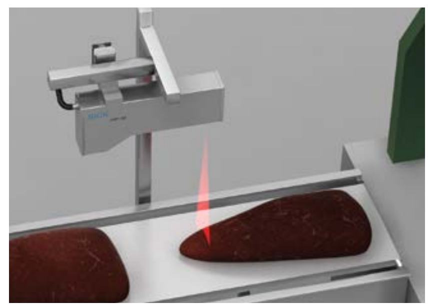
Robot belt picking
Finding the optimal gripping position is facilitated by 3D vision as objects with different texture are reliably detected, even if they are of the same color as the belt.



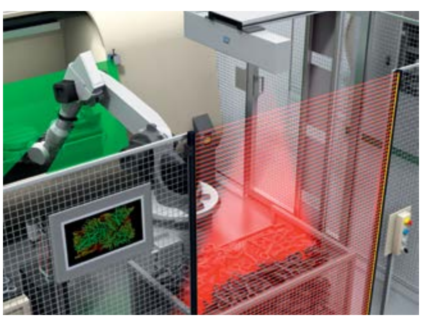
Box content verification
The presence and position of items in a box can be verified by 3D even if the contrast from the background is low.



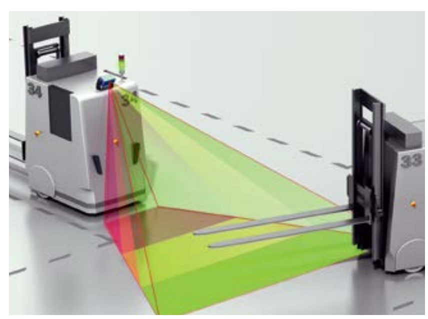
Electronics assembly
Position and presence verification of electronic component assemblies, as well as measuring co-planarity of, e.g., connectors, can be done with micrometer accuracy.



Food portioning
3D gives the total volume as well as the optimal cutting positions to get slices of equal size.



Robot bin picking
Unloading bins with randomly oriented parts requires 3D information in order to find the best gripping coordinates of the most suitable part to pick.



Obstacle recognition
A 3D snapshot camera creates a three dimensional image of the surroundings. If an obstacle is in the way, the AGV will try to go around or stop the movement and send an alarm.

Further links:
2D vision online
3D vision online
Vision catalog
SICK sensors YouTube channel

Sensor Intelligence.