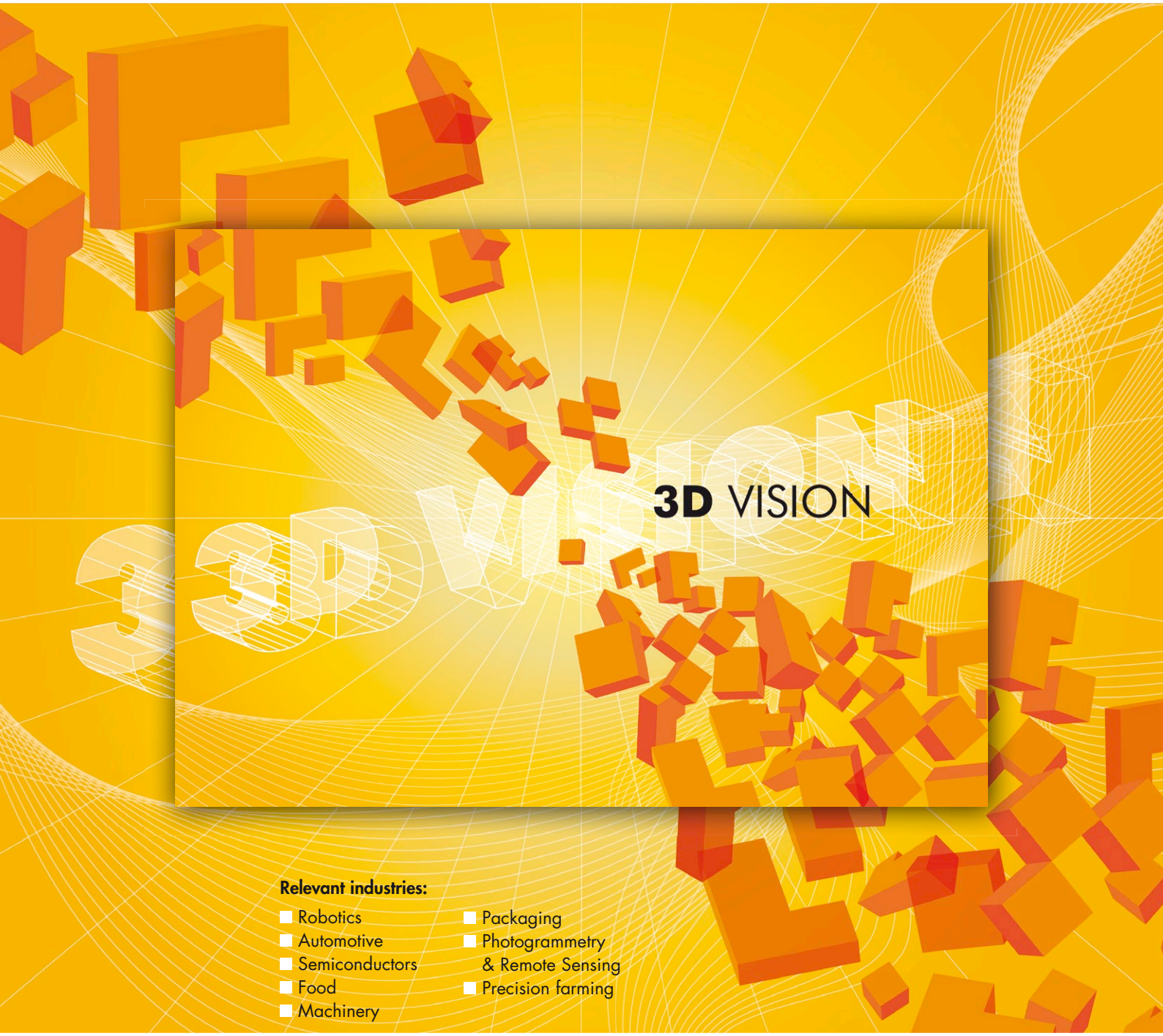
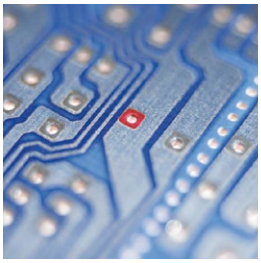
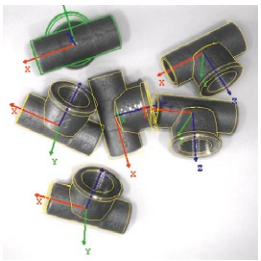
Machine vision know-how by MVTec

3D Vision – the Power of a new Dimension



3D ALIGNMENT
3D RECONSTRUCTION

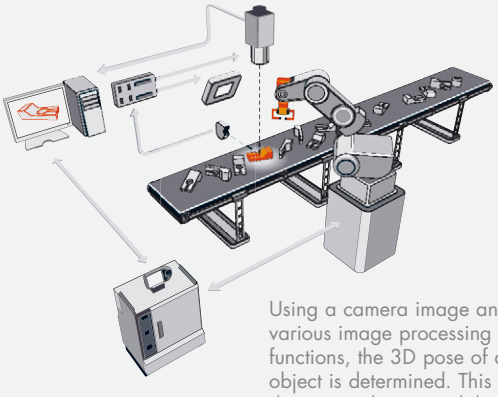




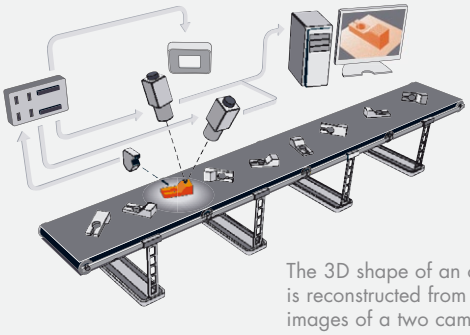
What is 3D Vision?

3D vision means the utilization of 3D information with the aid of machine vision, allowing to approach applications which so far could not be solved with classical 2D technologies. It includes two main objectives, which both contain many different technologies:

- 3D alignment – finding the 3D pose (position & orientation) of an object.
- 3D reconstruction – determining the 3D shape of arbitrary objects.



Using a camera image and various image processing functions, the 3D pose of an object is determined. This data is used to control the robot.



The 3D shape of an object is reconstructed from the images of a two camera setup.

From the Task to the Solution

For any project, in order to find a solution, you must identify the specific vision task. First, you should ask the following questions before deciding which 3D vision method is the right one for you:

Example used is bin picking

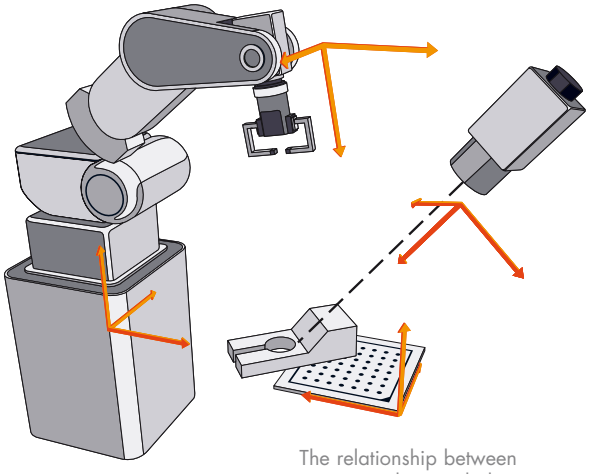
- What do I want to find out?
  Shape is known, position is required.
- How accurately do I want to measure?
  Adequate for the robot's movement.
- Which are the characteristics of my object?
  Object size 10-20 cm, reflective metal surface.
- What are the general conditions?
  Partially uncontrolled illumination conditions.

This analysis is very important, because the next step will be the decision which technology to use. The different technologies have various characteristics which must match the specific needs of your application.

3D VISION TECHNOLOGIES

3D Calibration

Introduction of the technology:
With 3D calibration, you establish the relationship between a camera and the object. For robotics applications, additionally the relationship between the robot and the camera is determined. With this technology, you get an explicit and accurate description of your area or line scan camera: A set of so-called internal and external camera parameters map the image coordinates to real world coordinates.

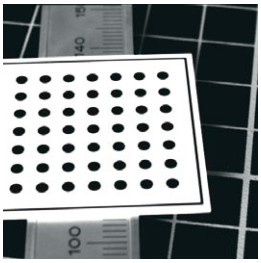


The relationship between camera, robot, and object is established with the help of a calibration plate.

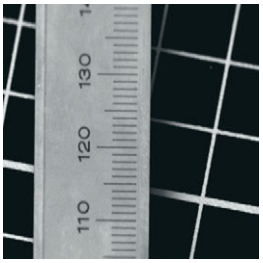
Particularly suitable for ...
The correction of lens and perspective distortions. This can be realized by rectifying the image, or by measuring in the distorted image and correcting the measuring result. Furthermore, measuring results can be determined in world coordinates and the geometric relationship between the camera and the object can be calculated by the calibration – crucial for robotics applications. All 3D applications require this technology. Typical examples include bin picking as well as stereo applications.

Supported by HALCON:
HALCON's 3D calibration supports both area and line scan cameras. 3D calibration works also with multiple cameras (multi-view 3D calibration). Usually, a specific calibration object is used for calibration (e.g., calibration plate). Alternatively, self-calibration, without the need of a calibration object, can be used. HALCON's 3D calibration permits, for example, subpixel-accurate measurements up to 1 µm in a field of view of 10 mm.

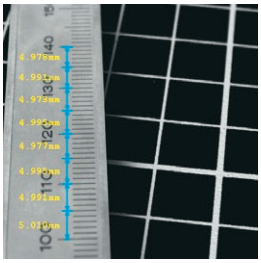
Application example:
3D calibration with HALCON for image rectification.



The calibration plate enables HALCON to perform the camera calibration.



HALCON rectifies perspective distortions.



Distances on the caliper can be measured in the presence of perspective distortions.

3D VISION TECHNOLOGIES

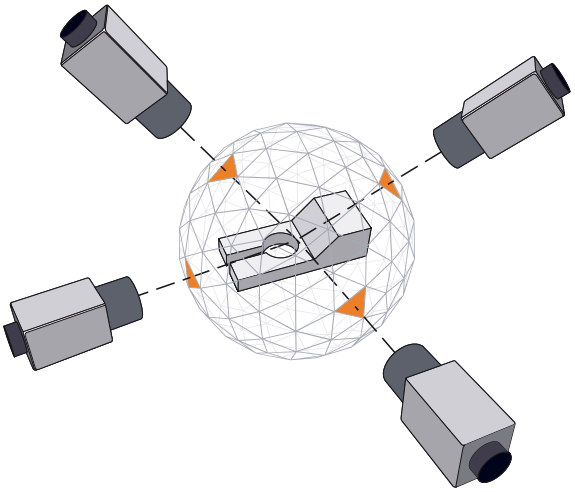
3D Matching

Introduction of the technology:
With 3D matching, it is possible to recognize and determine the 3D pose of arbitrary 3D objects even with only one camera.

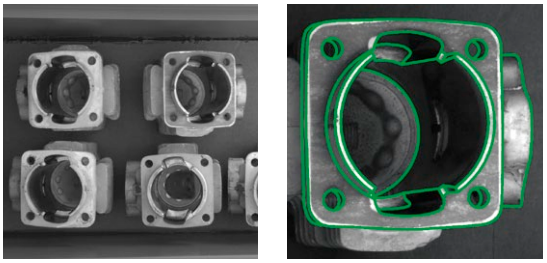
Particularly suitable for ...
3D alignment, i.e., finding the 3D pose (position and orientation) of an object, e.g., within automotive and robotics applications, pick-and-place applications, and bin picking. A further possibility is the measuring of geometric features on complex 3D objects after 3D alignment.

Supported by HALCON:
HALCON's 3D matching determines the 3D position and orientation of 3D objects. This is done by using the technology of shape-based matching extended to 3D by using multiple 2D views of the 3D object, represented by their CAD model. Alternatively, HALCON's surface-based 3D matching can be used, which is optimized to also find objects with a smooth surface. To gain highest accuracy, both methods provide a refinement of the pose in the full 3D space.

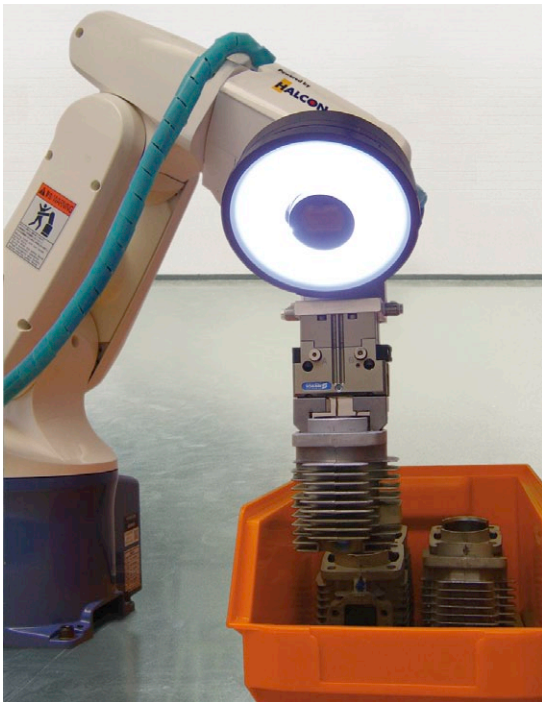
Application example:
3D matching for 3D alignment.



The object's 3D position and orientation is determined by matching multiple 2D views of a known 3D object.



Localization of a known object, control of the gripping process of the robot.



Perspective Matching, Circle Pose & Rectangle Pose

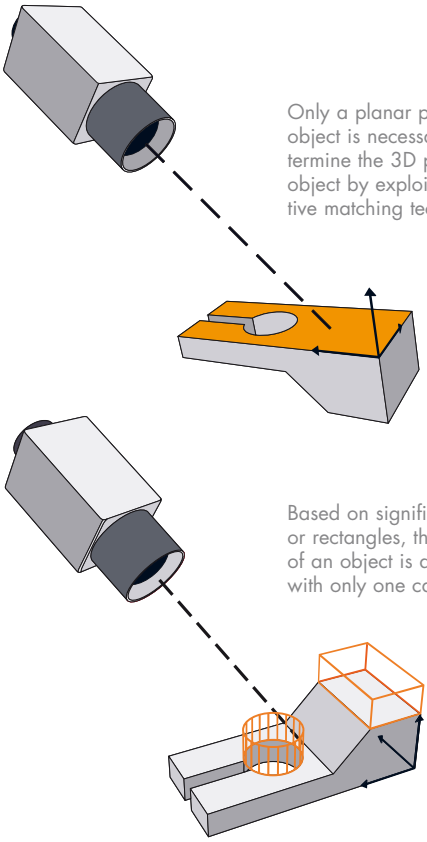
Introduction of the technology:
Instead of using the full 3D shape of an object, for many applications it is possible to restrict the model area to a planar part of the object.

- For arbitrarily shaped object parts, perspective matching allows to determine the 3D pose with only one camera. The model generation is done by training a sample image of the object typically inside a specified ROI.

- If the object has significant circles or rectangles, the 3D pose can easily be determined with only one camera. This is done by using the known size of the circle or rectangle to calculate the distance and the tilt angle of the object in respect to the calibrated camera.

Particularly suitable for ...
3D alignment, e.g., applications for which the 3D pose (position and orientation) of an object must be found. Examples are automotive and robotics applications, pick-and-place applications, and bin picking. A further possibility is the measuring of geometric features on complex 3D objects after 3D alignment.

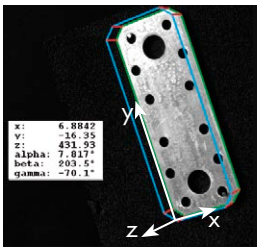
Supported by HALCON:
HALCON offers algorithms for both perspective matching and circle & rectangle pose. These methods help finding objects easily with only one camera.
For perspective matching, HALCON provides two different methods suitable for two different classes of objects. Depending on the object's shape and appearance, HALCON offers both deformable matching, which is based on the shape-based matching technology (object edges), and descriptor-based matching, which uses so-called interest points.
In case of circle and rectangle pose, HALCON offers highly accurate methods for the extraction of subpixel contours, either edges or lines. These contours are input for the robust fitting algorithms calculating the pose.



Only a planar part of the object is necessary to determine the 3D pose of the object by exploiting perspective matching techniques.

Based on significant circles or rectangles, the 3D pose of an object is determined with only one camera.

Application example:
3D alignment with rectangle pose.

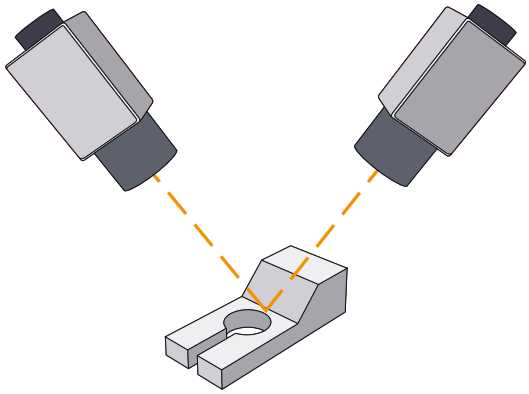


Calculating the 3D pose of the object by finding the rectangle.

3D VISION TECHNOLOGIES

Stereo Vision

Introduction of the technology:
The 3D coordinates of the visible points on the object surface can be determined based on two or more images that are acquired from different points of view. This is done by calculating the disparity map of the calibrated camera setup.

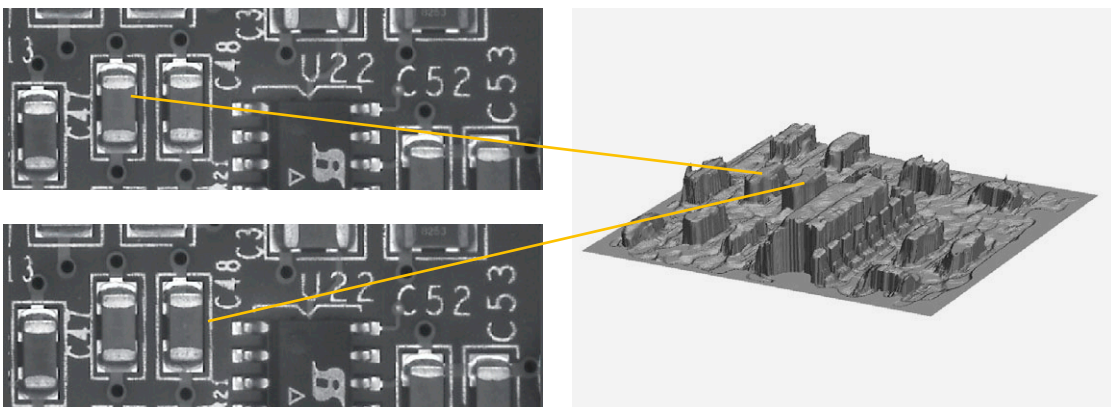


Two or more cameras acquire images from different points of view. The disparity map of these images is calculated and based on this, the 3D shape of the object is determined.

Particularly suitable for ...
3D reconstruction, i.e. determining the 3D shape of arbitrary objects, especially useful for mid- and large-sized textured objects. It can be used for quality inspection of 3D objects or for the position recognition of 3D objects. Furthermore, stereo vision can be a pre-processing step for 3D matching.

Supported by HALCON:
HALCON supports stereo vision by calculating the 3D coordinates on the object surface with the aid of a two camera setup (binocular) or multiple cameras (multi-view). This can be realized either by calculating dense 3D coordinates or distance images, or by determining the coordinates for specific points or edges – especially suitable for highly accurate height measuring. Furthermore, HALCON offers multigrid stereo – an advanced method to interpolate the 3D data in homogeneous image parts. This method yields higher accuracy for small objects.

Application example:
Binocular stereo with HALCON.



Calculating the 3D shape of the object using a calibrated two camera setup.

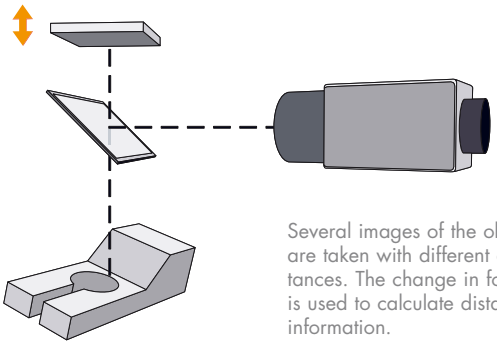
3D VISION TECHNOLOGIES

Monocular 2½ D – Depth from Focus & Sheet of Light

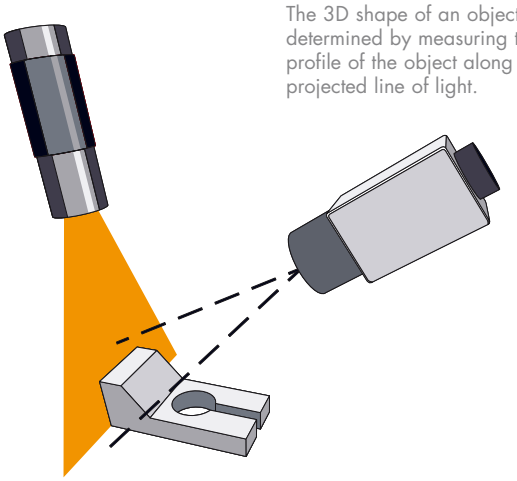
Introduction of the technology:
There are various so-called active technologies for the extraction of height information with one camera. The resulting 3D information is very similar to binocular stereo. The most often used methods are:

- Depth from focus (DFF) extracts distance information by calculating the focus of all pixels of the image. A small depth of field is used to calculate the distance of the object's surface to the camera.

- Sheet of light means measuring an elevation profile of an object by reconstructing the projected line of light on this object.



Several images of the object are taken with different distances. The change in focus is used to calculate distance information.

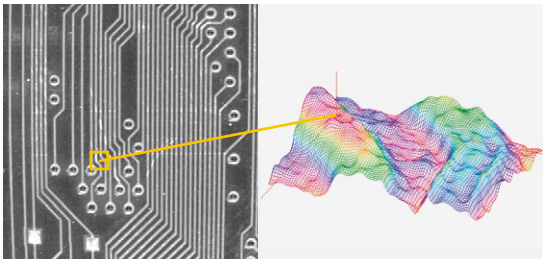


The 3D shape of an object is determined by measuring the profile of the object along a projected line of light.

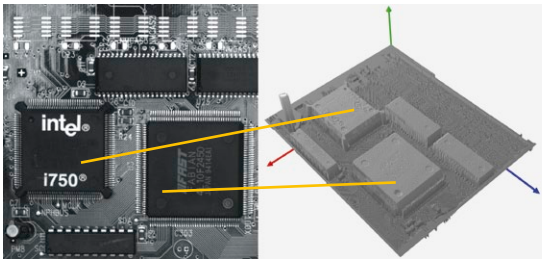
Particularly suitable for ...
3D reconstruction – in case of DFF especially suitable for small objects, in case of sheet of light for objects without texture. Typical application examples include quality inspection of 3D objects as well as position recognition of 3D objects.

Supported by HALCON:
For dense height maps, HALCON offers various methods that can be used to process 2½ D images, e.g., to determine object edges or angles between 3D planes. In the case of sheet of light, also highly accurate line- or point-oriented 3D measurements can be applied.

Application examples:
- Depth from focus with HALCON
- Sheet of light with HALCON



PCB trace inspection with DFF using HALCON.



Measuring the object with sheet of light using HALCON.

HALCON

the Power of Machine Vision

HALCON – the First Choice for 3D Vision

HALCON offers an outstanding amount of 3D vision methods – making it the only software you need for your application.

What is HALCON?

HALCON is the comprehensive standard software for machine vision with an integrated development environment (IDE) that is used worldwide. It leads to cost savings and improved time to market: HALCON's flexible architecture facilitates rapid development of machine vision, medical imaging, and image analysis applications.

Why HALCON?

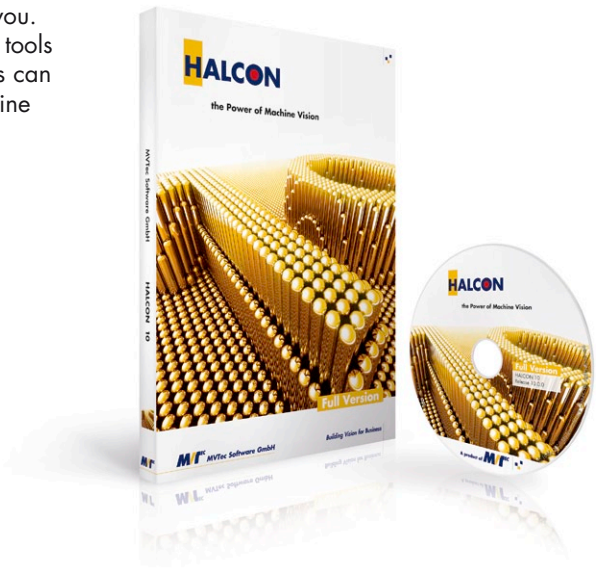
HALCON secures your investment: HALCON is the standard machine vision software with an outstanding amount of 3D vision methods. Whatever 3D vision methods your task needs now or in future, HALCON remains the right choice for you. Furthermore, HALCON offers a wide range of tools for post processing 3D data. All 3D algorithms can easily be combined with HALCON's 2D machine vision algorithms.

HALCON – a Product of MVTec

HALCON is developed by MVTec Software GmbH – the only software manufacturer worldwide purely developing software for machine vision.

Profit from MVTec's Competence!

MVTec employs highly qualified experts for machine vision with up to 20 years experience in this technology. These experts have also been acting as 3D vision pioneers by developing 3D vision technologies for more than 10 years. Experience is the key for knowing the requirements of specific applications. With HALCON, you acquire MVTec's long years of know-how in 3D vision applications.



Next Steps

- Use our free application evaluation service – describe your 3D vision task and see how HALCON can efficiently solve it: www.halcon.com/now
- Try HALCON for free! Download free demo version or request a free demo DVD: www.halcon.com/now
- Learn more during an in-house 3D vision training: www.halcon.com/now
- Read more in the HALCON documentation "Solution Guide on 3D Vision": www.halcon.com/documentation

MVTec www.mvtec.com

MVTec Software GmbH
Machine Vision Technologies
München, Deutschland