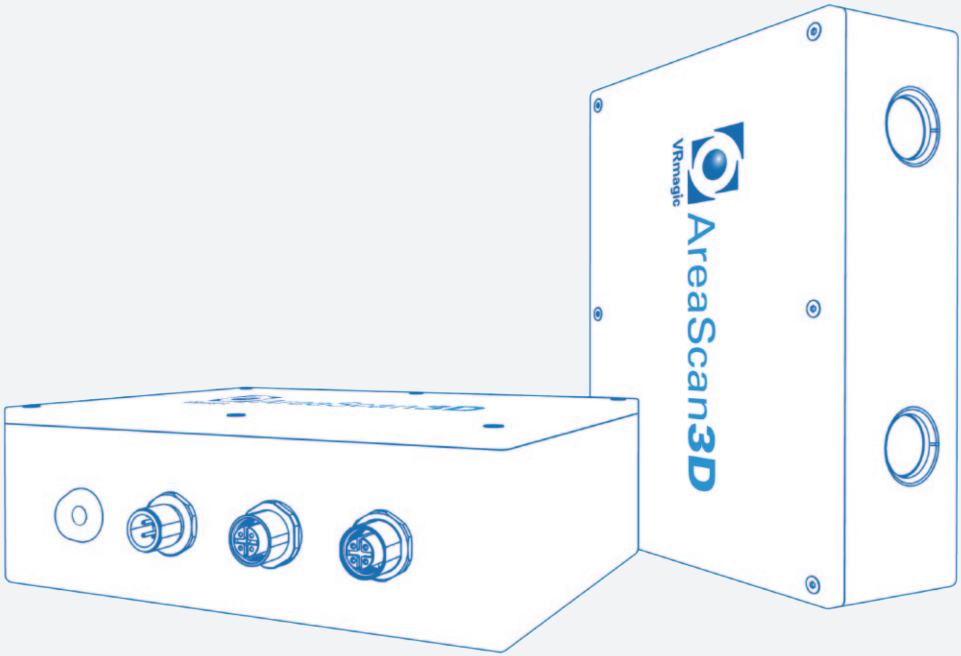
# AreaScan3D
# Manual




VRmagic

This manual (document version 1.1, date of issue 10/2011) is applicable to version 1.0 of the VRmagic AreaScan3D sensor. Subject to technical changes.

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# 1 Product Specifications

## 1.1 Introduction

With the AreaScan3D you hold in your hands a groundbreaking product in the area of optical 3D measurement, offering the following highlights:

- Optical 3D sensor based on digital fringe projection,
- Metric calibrated measuring data,
- Export formats: 3D point cloud or height encoding gray level image,
- GenICam transport layer compatible,
- Interfaces to Common Vision Blox & HALCON,
- Aluminum case, IP65 conforming,
- M12 standard industrial connectors,
- 24V operation,
- Ethernet.

## 1.2 Scope of Delivery

- Sensor, factory calibrated,
- CE/FCC-declaration / Canadian regulations,
- Quickstart manual,
- User guide (this document),
- Gauge R&R test,
- USB stick with software and documentation.

After delivery, check that the contents of the package are complete.

## 1.3 Intended Use

The VRmagic AreaScan3D is an area sensor. The device is intended to provide three-dimensional measurements of surfaces of a certain area and depth from a predefined distance. The field of application is industrial image processing. The measurements are transmitted via an Industrial Ethernet interface as ready-to-use 3D data sets.

## 1.4 Type Label


Fig. 1: Type Label

## 1.5 Measuring Principle

The 3D measurement method implemented in the sensor is based on triangulation.

Fringes (stripes) are projected onto an object. A camera sees the fringes from a different angle. The perspective deformation of the fringes seen encodes the 3D coordinates of object points along the fringes. With this basic principle alone, the distance resolution would depend on the camera resolution and the triangulation angle.

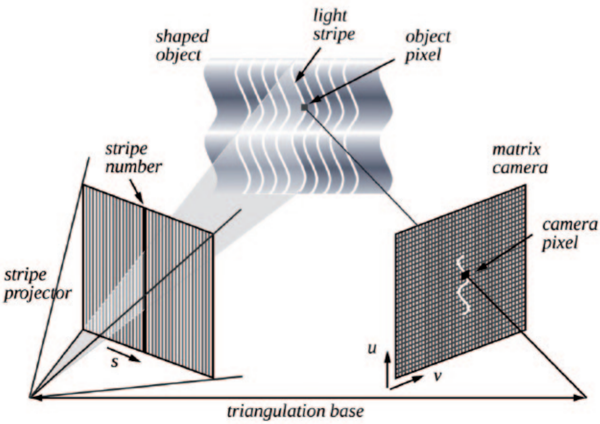


Fig. 2: Triangulation

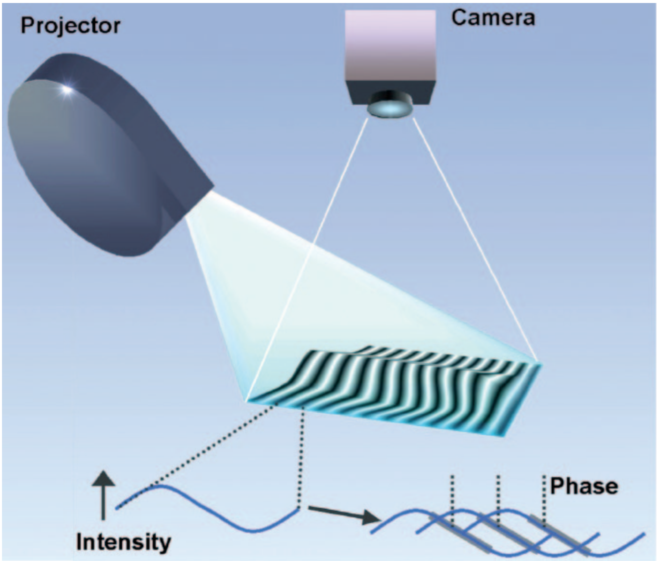


Fig. 3: Phase measurement

Phase measuring fringe projection, however, uses stripes that are not crisp, but have a sine-shaped brightness modulation. These stripes can be quite wide, as their position can be determined at high accuracy from the gray levels of the stripe flanks. The distance resolution here is no longer dependent on the camera resolution. Distance resolution can be measured more than 10 times more accurate, compared to mere triangulation.

In order to retain phase values for any point on an object, at least 3 fringe patterns with a phase shift of 1/3 fringe width are required (see following figure). In practice, at least 4 fringe patterns are used.

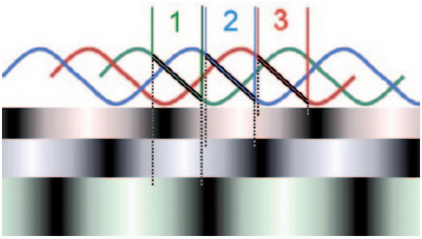


Fig. 4: Three patterns combined

Repeating patterns deliver no absolute distance indication, however. On highly fragmented surfaces it would not be possible to clearly identify the single fringes.

In order to assign each fringe seen to a proper distance range, a sequence of binary patterns is projected. Black and white patterns of stripes with varying width are used for this (see following figure). The sequence of brightness values results in a binary number which directly represents the stripe number. This number also indicates which particular stripe in the phase pattern is seen by a certain pixel of the camera. Hence, by a combination of binary and phase patterns, even highly fragmented objects are precisely measured in all detail.

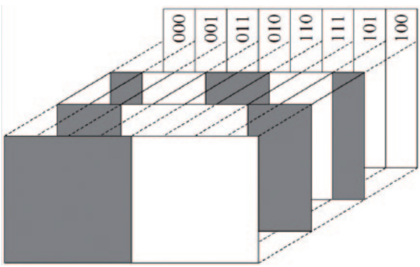


Fig. 5: Binary coded stripes

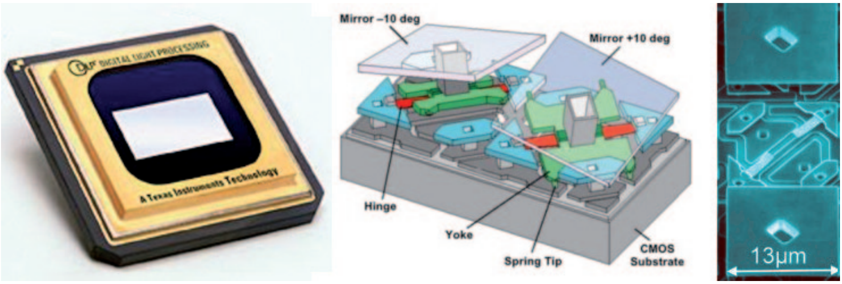


Fig. 6: DLP projection chip, 2 tilting mirrors (detail drawing), electron microscope image (Source: TI)

The projector used has to grant precise gray levels because of the phase measurement. Digital micro mirrors are best suited for this. Hundreds of thousands of microscopic tilting mirrors are arranged on a chip (Digital Micromirror Device (DMD)). These micro mirrors can switch positions within microseconds, by electrostatic force. Gray levels are generated by varying the on/off times. This results in digital precision. The DMD is the main component of the projector.

DLP projectors (Digital Light Processing) offer high efficiency, low temperature drift, and extreme durability (the mechanical components, etched from pure, monocrystalline silicon, do not know any material degradation).

# 2 Sensor Design

Projection unit, camera and signal processing components are enclosed in a protective housing conforming to IP65.

Projector and camera each work through a protective glass window.

The viewing angle of the camera is perpendicular to the case. The fringe projector has a slanted adjustment and throws its light into the camera‘s field of view. Therefore, an exact working distance is required.

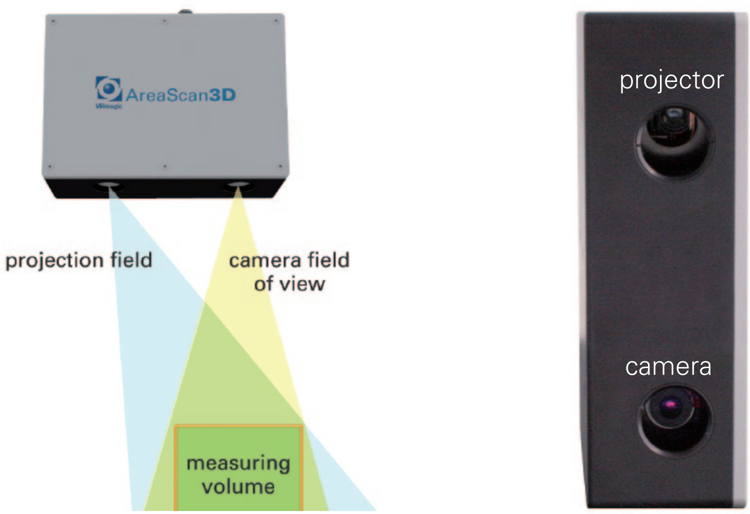


Fig. 7: Sensor design

# 3 Mounting

For mounting, the aluminum case of the sensor has six M6 thread bores at its bottom side. Depending on the mounting surface you will need suitable fastening material and tools.

The sensor should be mounted directly to a solid metal part. This ensures an optimum heat dissipation through the sensor case. Ensure that the ambient conditions are met (see “Technical Specifications” on page 22).

*Mounting the AreaScan3D*

1. Decide in which position the AreaScan3D is to be mounted (orientation, distance to the measured surface, see „Technical Specifications“ on page 22).
2. Vibrations can disturb the measuring process substantially. If necessary, use vibration absorbing components for mounting the sensor.
3. Pencil 6 mounting holes onto the mounting surface. The distance of the hole centers has to match the distance of the mounting hole centers on the AreaScan3D case (see following figure).
4. Drill 6 holes with sufficient diameters into the mounting surface.
5. Mount the AreaScan3D.

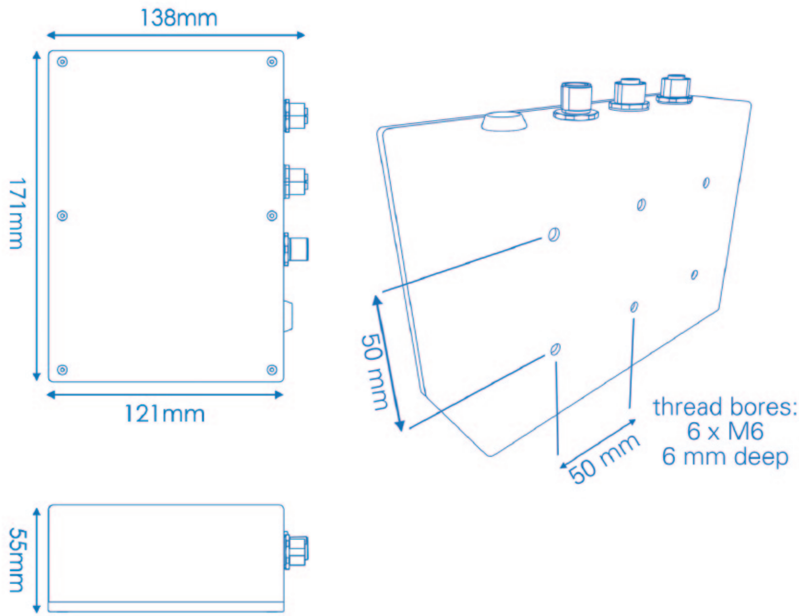


Fig. 8: Dimensions and mounting holes

# 4 Electrical Installation

## 4.1 Connections and Indicators

The sensor has 3 standard screw connectors according to IEC 61076-2-101 for M12 (see following figure).

| **Power: M12 A-coding 4-pin connector** | |
|---|---|
| Pin 1+2 | 24 V (18 ... 30 V DC, ripple < 2 V) |
| Pin 3+4 | GND |

| **Input/Output: M12 A-coding 8-pin connector (potential-free)** | |
|---|---|
| Pin 1 | Output 0 / +24 V, 100 mA |
| Pin 2+4+5+6 | GND |
| Pin 3 | Input 0 / +24 V |
| Pin 7 | reserved |
| Pin 8 | reserved |

The input and output connectors (I/Os) are protected against short-circuit, over-voltage and inversion and are potential-free.

| **100 MBit Ethernet: M12 D-coding 4-pin connector** | |
|---|---|
| Pinout | according to Industrial Ethernet standard |

| **Status LED (green)** | |
|---|---|
| LED off | no power supply (also possible directly after connecting) |
| LED flashes | sensor is booting (duration: approx. 1 minute ) |
| LED on | sensor ready |

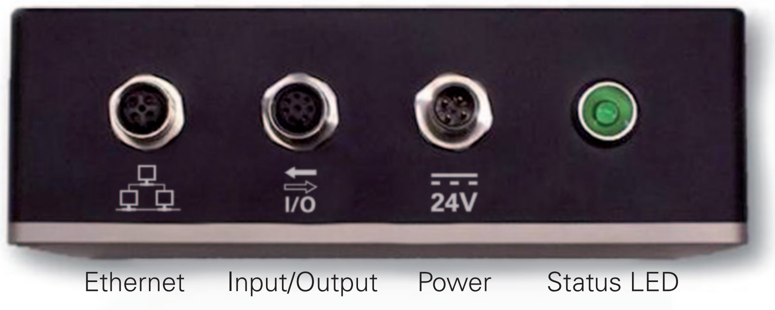


Fig. 9: Connections and indicators

## 4.2 Connecting the Sensor

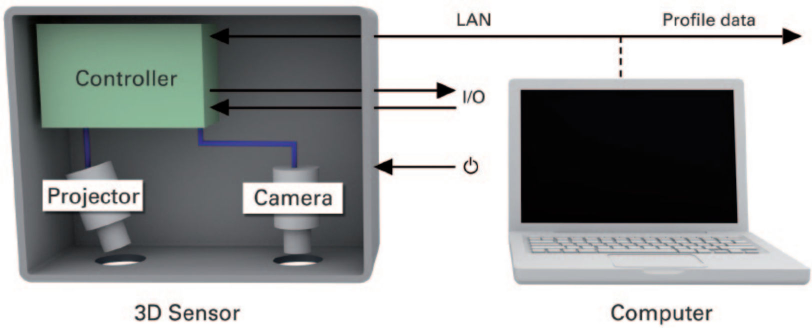


Fig. 10: Communications – block scheme

The sensor is controlled by the network (LAN) connection only. Any number of sensors can be connected to a network, also via switches or routers, similar to PCs and other network enabled devices.

> **Warning!**
>
> Possible damage to sensor.
>
> If the sensor is connected to a network by ODSCAD or another application and hence is active, the sensor should never just be switched off, or disconnected from the power source. This could, under unfavorable circumstances, cause damage to the sensor.
>
> Always deactivate the senor beforehand by closing the software application. Only then disconnect the sensor from power.

### *Connecting the AreaScan3D*

1. Connect the Ethernet connection of the AreaScan3D to an existing network or PC using an adequate Industrial Ethernet cable (see „Connections and Indicators“ on page 14).
2. The I/O lines (Input/Output, one each) can be configured for various functions via the software (e.g., the input as a trigger for starting a measurement).
3. Connect the AreaScan3D to a suitable power supply.
   - ⇨ After a short time, the status LED starts flashing. The sensor is not ready for operation while the LED flashes.
   - ⇨ After approx. 1 minute the LED stops flashing and stays on continuously. The sensor is ready.

Further procedures such as

- Finding the sensor address,
- Receiving a camera image,
- Software setup,
- Measurement,

are described in the software documentation on the provided USB stick.

# 5 Operation

## 5.1 Measuring Field Requirements

Contrary to 2D cameras, which can be focused to arbitrary distances, the 3D sensor requires the measured object to be in the field of view of both the camera and the projector. This defines a certain distance range and a certain common field of view, or measuring area.

The measuring volume of the 3D sensor is roughly determined by its lateral length and width, and by a depth range that lies around the optimal measuring distance (see following figure). These parameters have to be taken into account when positioning the sensor (see "Technical Specifications" on page 22).

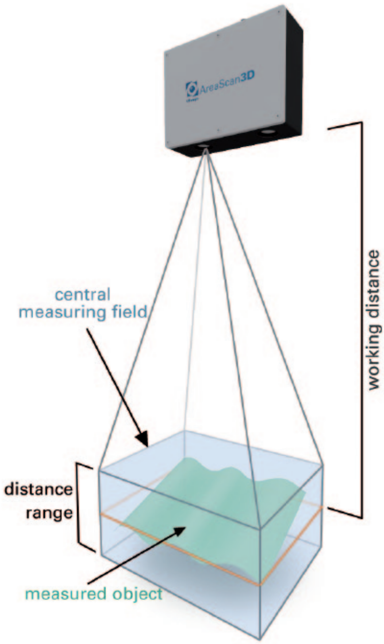


Fig. 11: Three-dimensional measuring volume

## 5.2 Positioning the Sensor

*Positioning the AreaScan3D*

1. Align the measured object surface as perpendicular as possible to the camera axis.
2. Project a cross-hair onto the measured object. The cross-hair can be selected in the user software. This serves for adjustment of both distance and positioning.
   - ⇨ The correct distance is adjusted when the projected crosshair appears in the center of the camera live image (see user software, live image display).
   - ⇨ The available measuring area results from the camera live image.
     **Note**: The measuring area is smaller than the area on the object illuminated by the projector. The projection always has a large reserve area in order to guarantee a complete coverage of the camera field of view at any distance within the specified distance range.
3. Because of the triangulation angle and the viewing angle of the camera, shadowing (areas not seen and therefore not measurable) can occur on steep edges. To minimize this effect, tilt the object accordingly.

## 5.3 Positioning the Measured Object

After the sensor has been positioned, the measured object most probably has to be aligned, too.

*Positioning the measured object*

1. Use the user software to project a static fringe pattern onto the object.
2. Position the object so that the predominant or the most undulated surface structures are aligned perpendicular to the stripes (see following figure). Aligning those surface structures parallel to the stripes would lead to larger triangulation angles up to the occurrence of shadowing and can also result in artifacts (height peaks) with strongly reflective surfaces.
   - ⇨ A good alignment is given if both wide and narrow fringes deliver a good contrast in the camera image over the entire surface area and depth range.
3. Depending on surface reflectance and local angles relative to the sensor, direct reflections of projector light into the camera can occur. This may result in excessive brightness values and may cause missing or wrong data at these points.
   If this is the case, tilt the object slightly. Keep an eye on the measured surface: it has to stay within the distance range of the central measuring field.

For further instructions refer to the software documentation on the provided USB stick.

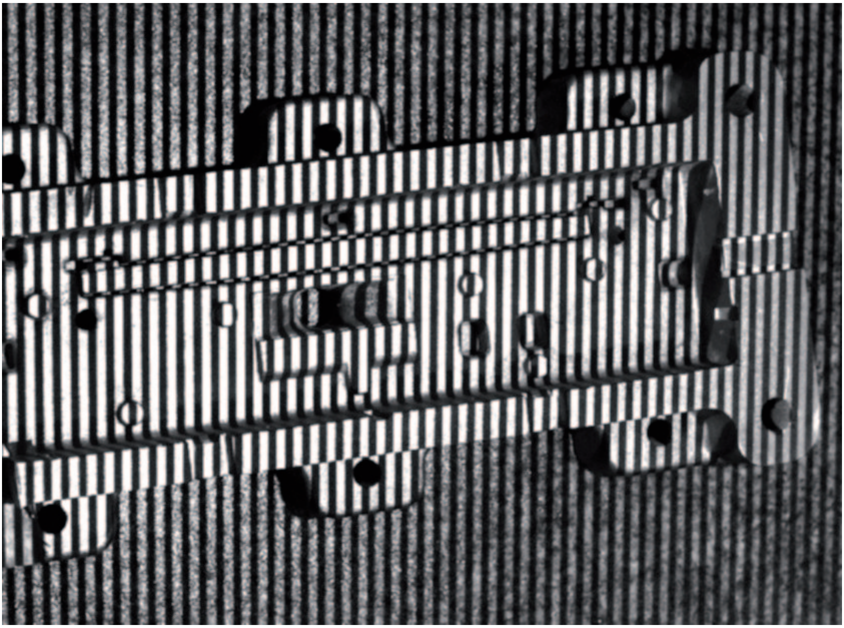

Fig. 12: Example for good alignment

# 6 Software / API

Refer to the separate software documentation on the provided USB stick.

# 7 Technical Specifications

## 7.1 Type-specific data

| **AreaScan3D 01-018** | |
|---|---|
| Measuring volume | 18 x 13 x 5 mm |
| Measuring points | 748 x 480 |
| Micro mirrors | 480 x 320 |
| Point density | 24 µm |
| Height resolution | > 4 µm |
| Working distance | 255 ± 1 mm (from lower case edge) |
| Min. working distance | 252.5 ± 1 mm (from lower case edge) |
| Max. working distance | 257.5 ± 1 mm (from lower case edge) |
| Min. projection time (time the object has to stand still) | < 0.5 s |
| 3D data calculation period | < 2 s |

| **AreaScan3D 01-120** | |
|---|---|
| Measuring volume | 120 x 75 x 50 mm |
| Measuring points | 748 x 480 |
| Micro mirrors | 480 x 320 |
| Point density | 160 µm |
| Height resolution | > 20 µm |
| Working distance | 285 ± 5 mm (from lower case edge) |
| Min. working distance | 260 ± 5 mm (from lower case edge) |
| Max. working distance | 310 ± 5 mm (from lower case edge) |
| Min. projection time (time the object has to stand still) | < 0.5 s |
| 3D data calculation period | < 2 s |

## 7.2 General data

| Dimensions, weight, ambient conditions | |
|---|---|
| Dimensions | 138 x 55 x 171 mm |
| Weight | < 1kg |
| Case temperature | 5 ... 40 °C (operating)<br>-20 ... +60 °C (storage/transport) |
| Max. temperature gradient (environment) | 1.5 K/min (operating)<br>2.5 K/min (storage/transport) |
| Relative humidity | 5 ... 90% (operating)<br>5 ... 95% (storage/transport) |
| Condensation | not allowed (operating)<br>to be avoided (storage/transport) |
| Altitude | 0 ... 3050 m (operating)<br>0 ... 13000 m (storage/transport) |
| Vibration | to be avoided (operating)<br><br>storage/transport:<br>sine, 5 g, 10 ... 500 Hz, all main axes (acc. to DIN EN ISO 9022-36-08-0)<br>random, 0.015 g2/Hz, 5 … 1000 Hz |
| Impact | to be avoided (operating)<br><br>storage/transport:<br>15 g, 11 ms half sine, all main axes,<br>max. 3 impacts per axis |

## 7.3 Conformity to Standards

| Applied standards | |
|---|---|
| Case sealing | IP65 |
| Optical emission power and eye safety | Free class / risk class 1 (no laser) |
| EMV test | acc. to EN 61000 |
| Mechanical stress | acc. to EN 60 947-5-2 |
| Electrical protection class | 1, acc. to DIN EN 61140 (VDE 0140-1) |

# 8 Troubleshooting

## 8.1 Hardware

| Problem | Possible cause | Remedy |
|---|---|---|
| Green LED off. | No supply voltage. | Connect power cable (24V) to power source and to AreaScan3D.<br>If possible, also measure the voltage at the plug. |
| Sensor does not work. | Reset not successful. | Remove power cable for 10 seconds, then reconnect. |
| Green LED permanently blinking (more than approx. 1 minute after applying power). | Reset not successful. | Remove power cable for 10 seconds, then reconnect. |
| Communication problem with PC (e.g., sensor not found), I/O problem. | Software | See software documentation. Also check network cable. |

## 8.2 Errors in 3D Image

| Problem | Possible cause | Remedy |
|---|---|---|
| 3D image has invalid-areas. | Area part too steep, too little light reaches the camera. | Turn object, use other viewing angle. |
| | Strong reflections. | Turn object, use other viewing angle or limit the field of view (see software manual). |
| 3D image has strong height peaks. | At abrupt area boundaries, some overshooting is normal. | Apply filtering (see software manual). |
| | Strong reflections. | Turn object, use other viewing angle or limit the field of view (see software manual). |
| 3D image has ripples in fringe direction. | Environment light has changed during measurement. | Avoid light changes, shield excessive light. |
| | Object or sensor moved during measurement. | Provide sufficient stabilization. |

VRmagic GmbH
Augustaanlage 32
68165 Mannheim
Germany
Phone +49 621 400 416-0
Fax +49 621 400 416-99

info.imaging@vrmagic.com
www.vrmagic-imaging.com

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