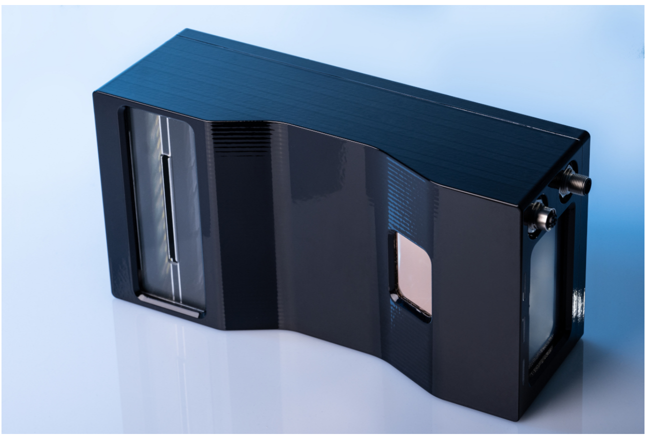
N1-500 Multispectral 3D Scanner



General Description

The **N1** is a 3D laser triangulation scanner with an integrated multispectral unit developed for part inspection and quality control applications. It measures 3D coordinates and reflectance in visible and NIR spectrum and merges the 3D and color data into multidimensional point cloud.

The **N1** combines two most widely used techniques for defect detection and quality control in one device, opening new possibilities for applications where both shape and color information are crucial.

Because of its line-scanning principle, the **N1** is ideally suited to applications in which parts are moving on the conveyor belt.

The **N1** acquires a sequence of signal/reference images at two different exposure settings to reliably eliminate image overexposure and maximize signal to noise ratio of dark areas, allowing measurements under most harsh conditions, including direct sunlight.

The **N1** provides a touchscreen for easy setup of the connectivity settings, measurement range, speed and synchronization method. The produced data can be monitored by 3D visualization tool running on the touchscreen. Most of the settings can be changed on the fly.

The point cloud data can be stored on the device and retrieved via API, or sent out via GigE interface immediately for user side processing. Alternatively, the point cloud can be processed on the device by user application with an option to control the external actuators, PLCs or sensors via user programmable DIOs and/or RS232 interface directly.

The **N1** is available in 3 versions:

- **N1-200**: High resolution, measurement range 200mm.
- **N1-500**: Standard, measurement range 500mm.
- **N1-1000**: Long range, measurement range 1000mm.

Features

- 3D and multispectral measurements in one device
- Easy integration into conveyor systems
- Robust 3D measurement by laser triangulation
- Stable, ambient light independent colors by active illumination
- RGB and two NIR color coordinates
- Measurements in direct sunlight
- Scanning speed up to 1500 Hz
- Touch screen for easy setup
- On-board data processing and storage for user applications
- Battery backup for maximum data integrity
- Gigabit Ethernet, RS232 and 4x DIOs

Applications

- inline quality control
- organic materials
- food processing

Table 1: N1-500 specification overview

	Parameter	Value
OPTICAL	Measurement range, Z-axis	250 .. 700mm
	Measurement range, X-axis	225mm @ Target distance Z=250mm 520mm @ Z=700mm
	Data points per profile	2048
	Max. scanning rate	1000 Hz / 1500 Hz in HDR / FAST mode, reduced Z-range 175 Hz / 350 Hz in HDR / FAST mode, full Z-range
	Resolution, X-axis	0.11mm @ Z=250mm 0.26mm @ Z=700mm
	Spectral bands (R/G/B/NIR)	630/550/475/735/940 nm
	Color depth	16 bit
	Laser class	1M
SYSTEM	System setup	Touchscreen: Connectivity settings, Measurement range, 3D preview Web Interface: Full parameterization REST API: Process integration
	Synchronization modes	Freerun, encoder, API
ELECTRICAL	Supply voltage	18..30 VDC
	Power consumption	max. 50 W @ supply voltage 24 VDC
	Power supply buffering time	min. 1s @ 1500 Hz in FAST mode (=max. power consumption)
	On-battery run-time	min. 5s
I/O	User programmable I/O	4x high power 24 V x 500mA source/150mA sink DIO
	Encoder input	24 V level, single-ended
	RS232 interface	user-programmable
	Ethernet interface	Gigabit Ethernet
	Power/IO connector	M12 12p. male
	Ethernet connector	M12 8p. X-coded
MECHANICAL	Dimensions	286 x 150 x 91.5 mm
	Weight	3.2 kg
	Operating temperature	0..40 ℃
	Relative humidity	0..100 %
	Protection class	IP65

Measurement principle

3D measurement

The **N1** measures the 3D coordinates by laser triangulation method. The 3D unit has a laser line generator projecting thin laser line on target and the 3D camera. By measuring the laser line displacement on the 3D camera image, the N1 calculates the distance Z and the lateral coordinate X of the object along the laser line.

Multispectral measurement

The multispectral unit (s. Fig. 1) measures near-normal reflectance of the target in visible (RGB) and NIR (730nm) spectral range. It has a high power LED flash unit, the collimating optics, the diffusor, and the multispectral camera. The LED light is shaped by the collimating optics and the diffusor into the narrow stripe pattern. The multispectral unit is aligned in a way that the projected light stripe overlaps the laser line.

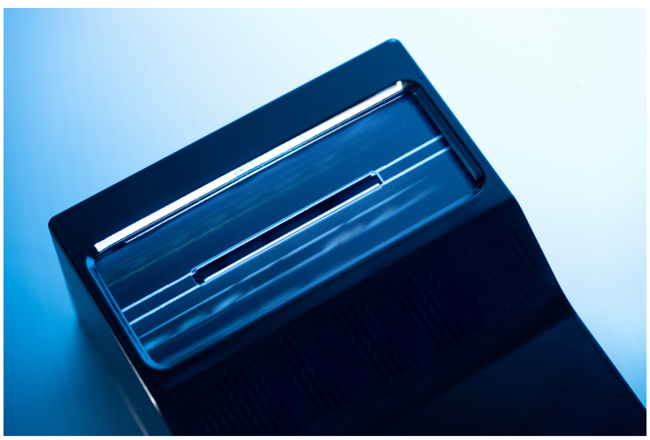


Figure 1: Multispectral unit

The reflected light intensity is measured by the multispectral camera. The multispectral camera takes images with LED flash ON and OFF for each color channel (R,G,B,NIR730). By substracting the reference images (LED flash OFF) from the signal images (flash ON), the effects of ambient light can be eliminated.

Data fusion

In order to calculate the RGB and NIR color coordinates, the corrected image intensities (R,G,B,NIR730) and the laser intensity (940nm) are assigned to the corresponding 3D points and normalized. The resulting point cloud (s. Fig. 2) has a format (X,Y,Z,R,G,B,NIR730,NIR940), where X,Y,Z are the point position in mm (float 32b) and color coordinates are 16 bit integers.

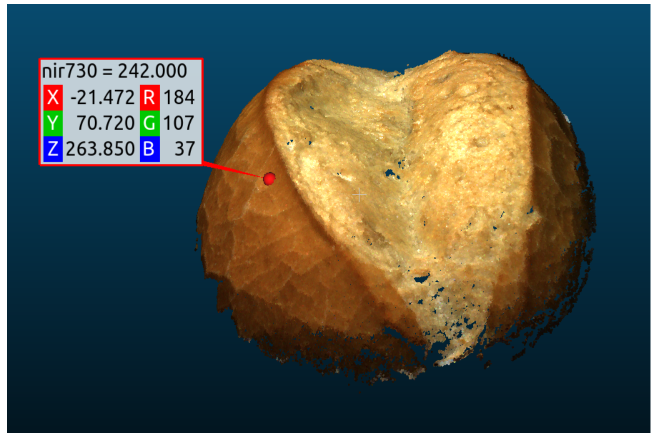


Figure 2: Multispectral 3D scan of bread

Measurement modes

The **N1** supports FAST and HDR measurement modes. The FAST mode is designed for the applications where the highest scanning rate is required. It works best under moderate ambient light conditions (indoor, factory lighting, no strong reflections). The HDR (high dynamic range) mode should be applied at harsh ambient light conditions (direct sunlight) and when working with very inhomogeneous materials (high contrast, very reflective materials, glossy surfaces).

FAST mode

In FAST mode, one 3D camera image (laser ON) per profile is used. The background light in 3D image is subtracted by image processing algorithm. While delivering good results with low to moderate ambient light conditions, this method could potentially fail at strong ambient light, resulting in 3D noise and artifacts in the final point cloud.

For multispectral measurements, one signal (flash ON) and one reference (flash OFF) image per each color channel are acquired. The exposure time is chosen to balance competing signal-to-noise and ambient light sensitivity considerations. The images can become overexposed when measuring glossy objects and/or under strong ambient light conditions.

HDR mode

In HDR mode, one signal and one reference 3D camera images per profile are used. The background light is removed by subtracting the reference from the signal image. Since the reference image is acquired directly, this methods provides the best possible background light rejection.

For multispectral measurements, a sequence of two signal (flash ON) and two reference images (flash OFF) per each color channel is acquired. The images are taken at two different exposure settings. The shorter exposure time is chosen to prevent image overexposure at strong light conditions (highly reflective objects close to scanner, strong reflections, strong ambient light), while the images taken at longer exposure time provide excellent signal-to-noise ratio for darker areas. The best of the two background corrected images is taken for color calculation and normalized to its exposure time.

Maximum measurement range

The maximum measurement range is described by a symmetric trapezoid shape defined by angle of view of 3D camera, s. Fig. 3. The X-range (width) is linearly increasing from ±112.5mm at object distance Z=250mm to ±260mm at object distance Z=700mm.

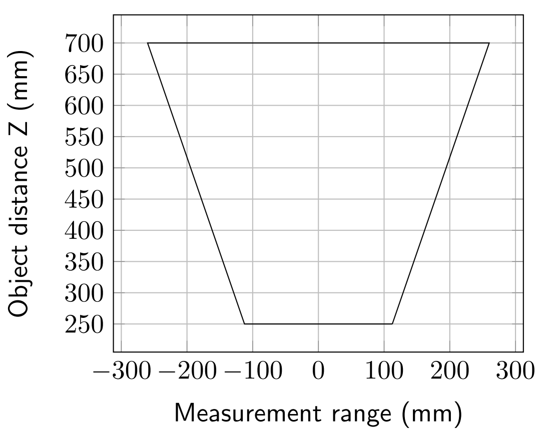


Figure 3: Maximum measurement range

Maximum scanning speed

The maximum scanning speed depends on the selected Z-range and the operating mode. By restricting the Z-range (distance) the scanning speed can be increased. Depending on the measurement mode, scanning speed of up to 1500 Hz can be achieved. Fig. 4 and Fig. 5 show the two cases when the object is placed far (close to Zmax) and close (near Zmin) to scanner.

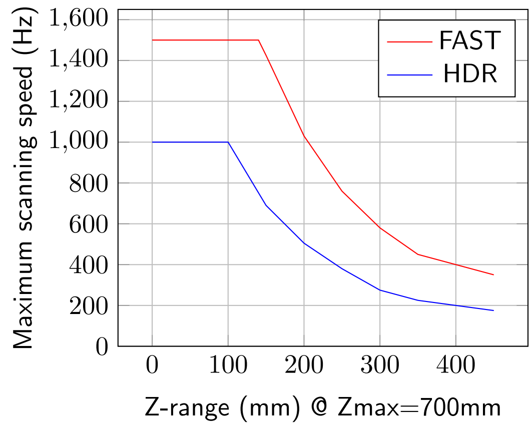


Figure 4: Maximum scanning speed, object far from scanner

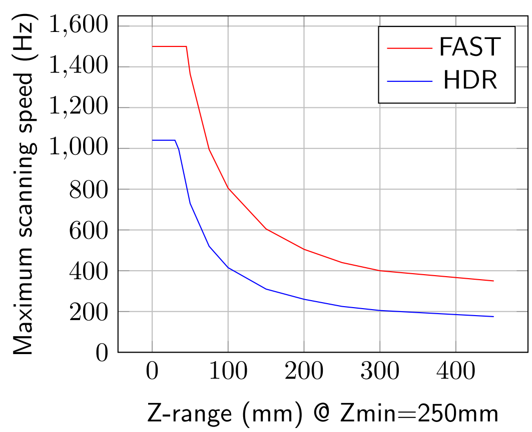


Figure 5: Maximum scanning speed, object close to the scanner

Resolution

The X-resolution is determined by the object distance and the resolution of 3D camera sensor (2048 pixels). The X-resolution depends linearly on the object distance Z, s. Fig. 6. It can be estimated as $X_{RES} = X_{RANGE}/(points\_per\_profile) = X_{RANGE}/2048$.

The Z-resolution depends strongly on object distance Z as well as its reflectivity, surface roughness and homogeneity. The Z-resolution data should be considered as achievable resolution for reasonably uniform matte surfaces and properly setup 3D camera exposure time.

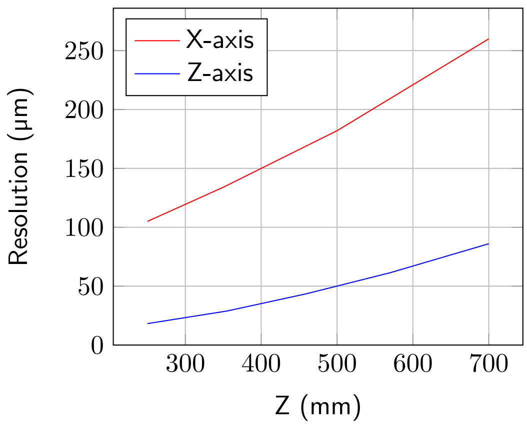


Figure 6: Resolution

Figure 7: Touchscreen

Summing up, placing the scanner close to the measured object will improve the resolution at cost of measurement speed and measurement range. This needs to be considered when choosing the working distance.

Setup and troubleshooting

The **N1** has powerful and easy to use tools for system parameterization, integration, test runs and troubleshooting:

- Touchscreen (s. Fig. 7): for easy initial setup of IP address, measurement mode, measurement range, exposure time, and synchronization mode. The changes can be applied on the fly without interrupting the measurement process. The 2D/3D visualization tool helps to setup the system correctly and identify the potential issues.
- Web Interface: for full parameterization of the **N1** including upload, logging and debugging of user applications. Needs the direct network connection to **N1**.
- REST API: for system integration and customization. Provides full access to connectivity settings, measurement mode parameters, scanning speed, measurement range, DIO, encoder, and user application parameters. Please contact us for complete documentation.

Start the measurement

The measurement can be started by:

- Hardware: pull ENABLE (pin 3 of IO connector, s. Table 4) high to start the measurement.
- Touchscreen: press PLAY icon in Preview tab to start the measurement.
- Web Interface: press PLAY icon.
- API: SCAN_START command.

Synchronization modes

The following synchronization modes are supported:

- FREERUN: continuous profile acquisition, fixed speed.
- ENCODER: profile triggered by encoder signal. Supports forward, backward, any direction modes and a programmable divisor.
- SOFTWARE: profile triggered by API command.

On-board data processing

The **N1** provides integrated PC with a quad-core processor and 4GB RAM for user applications. The user application controls the data acquisition process (START / STOP signals, profile synchronization, etc) via REST

API. The user application has full access to DIOs and RS232 via API as well.

The user application can be uploaded to **N1** via Web Interface or REST API.

The **N1** provides a battery backup system that can buffer the input power interruptions for up to 1s without affecting the measurement process. When the power shortage sustains for longer than 1s, the device leaves the measurement mode, sends the termination signal to the user application and shuts down the integrated PC ("graceful shutdown"). This reduces the risk of data lost and the risk of the system going into an uncontrolled state.

Communication

The **N1** provides Gigabit Ethernet, RS232, encoder input and 4x high power digital in-/outputs for system integration, s. Table 2 and Table 3 for details.

Mechanical and environmental specifications

Please refer to Table 5 for mechanical and environmental specifications and Fig.8 for device dimensions.

Contact

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Table 2: Connectivity

Interface	Function
Gigabit Ethernet	Raw data output for external processing UDP/WebSocket Web Interface Device API
RS232	User programmable, 115200Bd Communication to external devices (PLC, drives, actuators, sensors) Sending out processed data (object coordinates and grade)
DIO1..DIO4	User programmable high power DIO Direct control of external devices (valves, pneumatics, actuators) Direct sensor connection

Table 3: Electrical specifications

Parameter	Min.	Typ.	Max.	Units	Conditions
Supply voltage[1,2]	18	24	30	VDC	
Power consumption[1,2]			35	W	
DI max. voltage			42	V	DIO configured as input
Input voltage low[3]			7.2	V	DIO configured as input, supply voltage 24V
Input voltage high[3]	16.8			V	
DO source current limit	500	580	700	mA	DIO configured as output, supply voltage 24V, V_{OUT} = 21.0V
DO sink current limit	150	200	280	mA	DIO configured as output, V_{OUT} = 2.0V
Power supply buffering time	1			s	Scanning at 1500 Hz in FAST mode (=max. power consumption)
On-battery run-time	5	14	20	s	

[1] Voltage drop in supply cable needs to be considered. Power consumption and voltage drop rise when DO are driving significant loads, s. DIO output specifications. Max. supply cable length is 10m for 0.25mm^2 (AWG24) cable.
[2] The device complies to EN55022/32 Class B conducted emission limits.
[3] Digital inputs compliant with IEC61131-2 Type 1/3 specification.

Table 4: IO connector

Pin	Signal	I/O	Description
1	PWR	I	Power supply 24 VDC x 1.5A min.
2	GND		Power/Signal ground
3	EN	I	Start/stop scan
4[1]	READY	O	Asserted when boot is finished and device is ready to scan.
5	ENC_A	I	Encoder A input (24V)
6	ENC_B	I	Encoder B input (24V)
7	RX	I	RS232 RX
8	TX	O	RS232 TX
9[1]	DIO1	I/O	User programmable DIO (24V, 0.5A source / 0.15A sink capacity).
10	DIO2	I/O	
11	DIO3	I/O	
12	DIO4	I/O	

[1] All 24V outputs (DIO1..DIO4, READY) are short-circuit and thermally protected.

Table 5: Mechanical and environmental specifications

Parameter	Value
Dimensions	286 x 150 x 91.5 mm
Weight	3.2 kg
Operating temperature	0..40 ℃
Relative humidity	0..100 %
Protection class	IP65

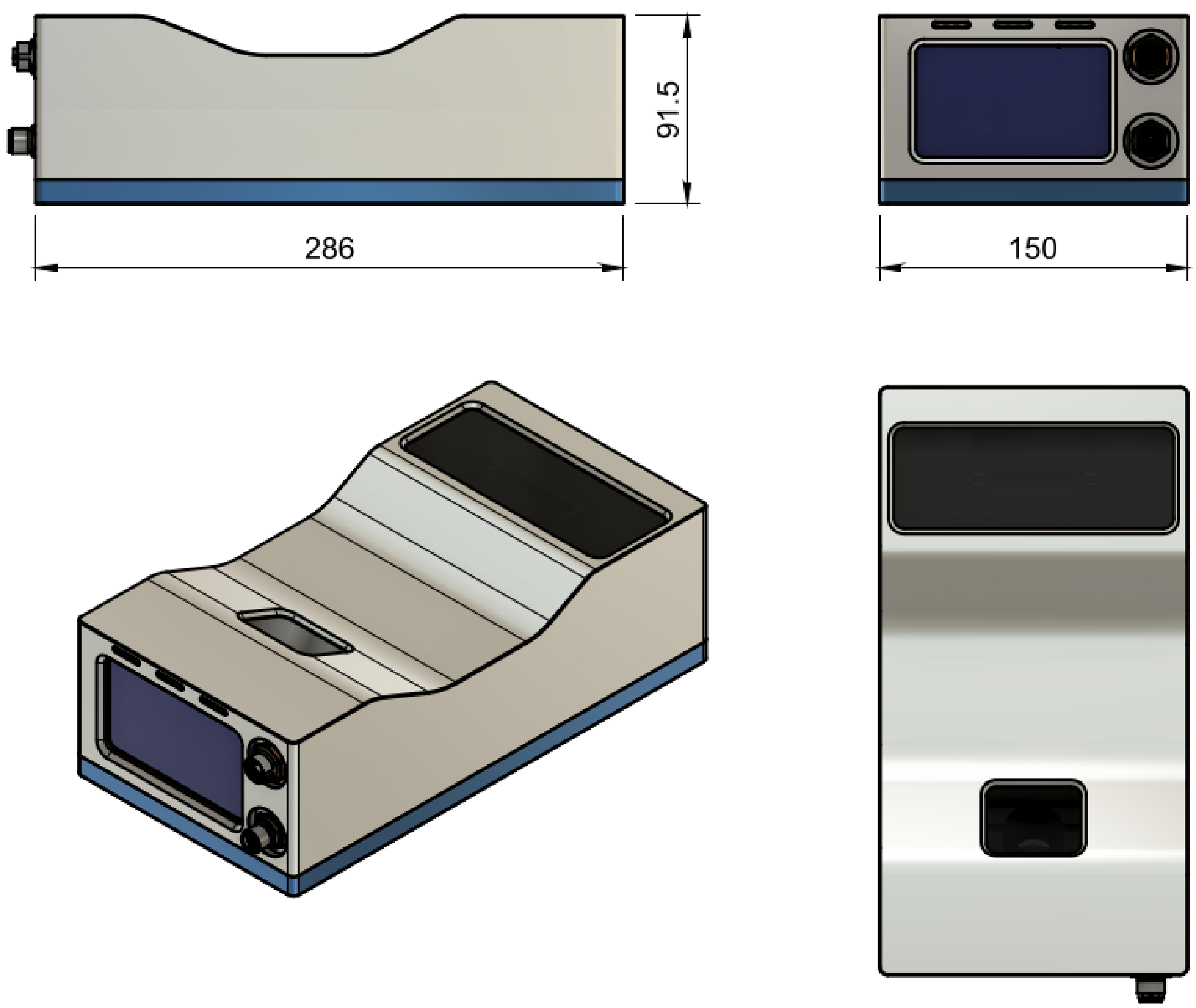

Figure 8: N1 dimensions