NODAR

HDK Nano

Datasheet

Hammerhead Development Kit

Ultra-Wide Baseline Stereo Vision for Ultra-Long-Range Detection

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Technical Specifications v1.0

NODAR Inc. / NODAR Sensor GmbH
nodarsensor.com

OVERVIEW

Welcome to the NODAR HDK Nano

The NODAR HDK Nano is the compact variant of the Hammerhead Development Kit (HDK), a complete stereo vision platform for evaluating and integrating ultra-wide baseline depth perception into autonomous vehicles, robotics, and industrial automation systems. The HDK Nano ships with automotive-grade 5.4 MP HDR stereo cameras, paired with an NVIDIA Jetson Orin Nano processing unit pre-loaded with NODAR Hammerhead software, delivering color point clouds and occupancy maps out of the box.

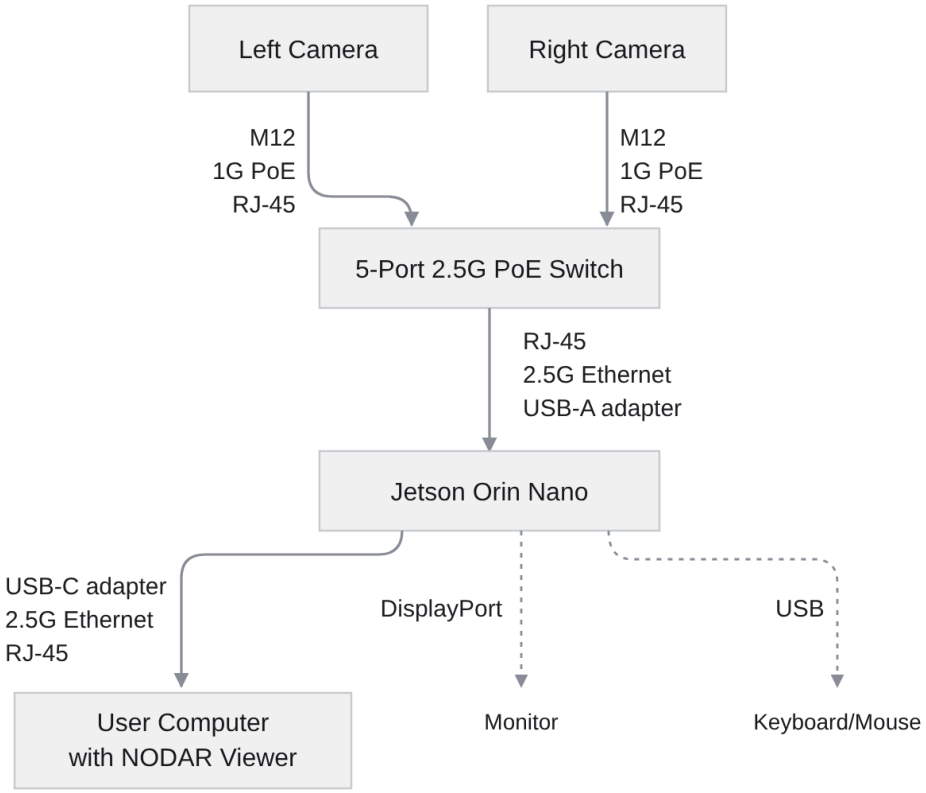
Ultra-wide baseline stereo vision revolutionizes depth perception by expanding baseline distances from 100 mm to 1000 mm — 10 times wider than conventional setups. This extended baseline increases depth accuracy and range by a factor of 10, enabling precise 3D vision over greater distances for applications in autonomous vehicles, robotics, and industrial automation.

Experience the power of HDR Stereo Vision!

System Architecture

The left camera and right camera are each connected to a 5-port 2.5G PoE switch via PoE (Power over Ethernet), enabling power and data transmission through the same cable. The switch supplies power to both cameras and connects to the Jetson Orin Nano through a USB-to-Ethernet adapter on a USB-A port. Both cameras share this single 2.5G link, which carries the combined data rate of the stereo pair. A second USB-to-Ethernet adapter, on the USB-C port, carries data out to the user system over 2.5G Ethernet at the static address 10.10.1.10. The Orin Nano also connects to a monitor using DisplayPort, providing a visual interface for output. Additionally, the Orin Nano is connected to a keyboard and mouse through USB, enabling user interaction for system control.

The NODAR Viewer can be installed on the Orin or the user computer. Note that the Viewer takes up GPU resources. It is strongly recommended to run the Viewer on the user computer and not on the Orin.

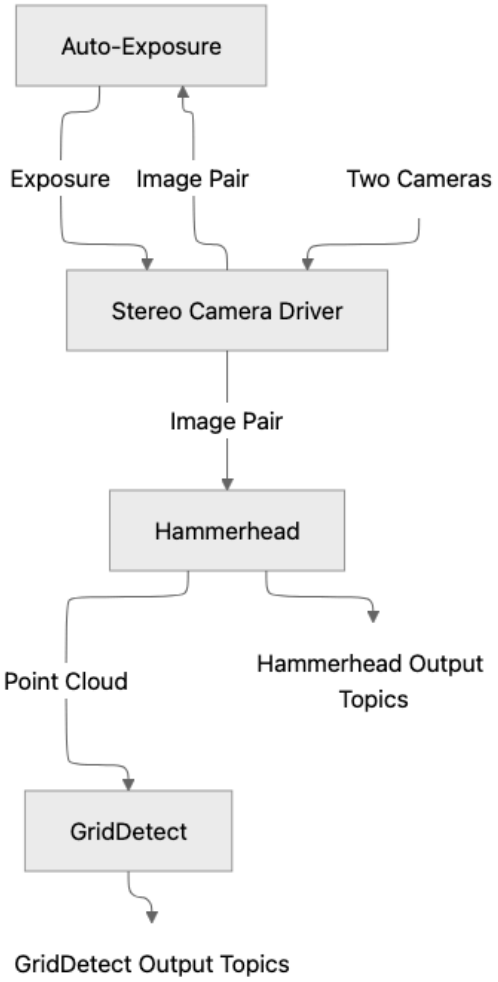


HDK Nano Software Stack

NODAR HDK software runs on the Jetson Orin Nano and consists of three blocks:

- Stereo Camera Driver - captures images from two cameras.
- Auto-Exposure - automatically sets the camera exposure for both left and right cameras. The feedback loop is limited to approximately 1 second.
- HDK API - converts raw images into high-quality color point clouds and occupancy maps. Supports ROS2, ZeroMQ, and a ZeroMQ/ROS2 bridge.

The input and output topics are discussed in the linked API documentation. Data fields that can currently be recorded through the NODAR Viewer are found on the NODAR Documentation site.


Auto-Exposure
Exposure
Image Pair
Two Cameras
Stereo Camera Driver
Image Pair
Hammerhead
Point Cloud
Hammerhead Output Topics
GridDetect
GridDetect Output Topics

SPECIFICATIONS

Camera Specifications

Parameter	Value
Class	Automotive
Format	5.4 MP HDR
Resolution	2880 × 1860 pixels
Pixel Size	3 µm
Shutter	Rolling Shutter
HDR Type	Two photodiodes and four TIAs
Dynamic Range	120 dB
Companded Bit Depth	16-bit
Exposure	86 µs to 47 ms
Gain	0 to 30 dB
Ingress Protection	IP67
Focus	Infinity
Lens Mount	S-mount
IR Filter	650 nm cutoff
Synchronization	PTP (IEEE 1588)
Camera-to-Camera Timing Jitter	10 µs average, <20 µs maximum
Data Rate per Camera	<1 Gbit/s (800 Mbit/s typical)

Lens Options

Option	Focal Length	Ingress Protection
30° FOV	16 mm	IP67
65° FOV	6.8 mm	IP69
135° FOV	4.0 mm	IP69

3D Specifications

Parameter	30° FOV	65° FOV	135° FOV
Horizontal Field of View	30°	65°	135°
Vertical Field of View	19.4°	42°	87°
Baseline B	0.5 m or 1 m	0.5 m or 1 m	0.5 m or 1 m
Disparity Search Range	Up to 1024 pixels	Up to 1024 pixels	Up to 1024 pixels
Minimum Depth (Z□), 1 m baseline	Down to 5.23 m	Down to 2.20 m	Down to 1.30 m
Minimum Depth (Z□), 0.5 m baseline	Down to 2.62 m	Down to 1.10 m	Down to 0.65 m
Maximum Depth (±2% range error), 1 m baseline	Up to 1067 m	Up to 450 m	—
Maximum Depth (±2% range error), 0.5 m baseline	Up to 533 m	Up to 225 m	—
IFOV (Instantaneous Field of View)	0.01°	0.026°	0.043°
Focal Length (f = 1/IFOV)	5333 pixels	2250 pixels	1333 pixels

Disparity is related to depth by the equation $D = \frac{fB}{z}$, where D is the disparity in pixels, f is the focal length in pixels, B is the baseline length, and z is the depth to the object.
Instantaneous Field of View (IFOV) is the angle subtended by one pixel.

Disparity Discretization

Disparity Range	30° FOV	65° FOV	135° FOV
0–127 pixels	1/16 pixel	1/16 pixel	1/16 pixel
127–511 pixels	1/8 pixel	1/8 pixel	1/8 pixel
511–1023 pixels	1/4 pixel	1/4 pixel	1/4 pixel

Disparity Error

Condition	30° FOV	65° FOV	135° FOV
Good weather	±0.1 pixel	±0.1 pixel	±0.1 pixel
Bad weather (32 mm/hr rain)	±0.3 pixel	±0.3 pixel	±0.3 pixel

Disparity error is median disparity when measuring a flat target.

Depth Precision — Good Weather

Range	30° FOV (1 m baseline)	65° FOV (1 m baseline)	135° FOV (1 m baseline)
10 m	±0.8 cm	±0.8 cm	±0.8 cm
20 m	±1.6 cm	±1.8 cm	±3.0 cm
30 m	±2.4 cm	±4.0 cm	±6.8 cm
50 m	±4.7 cm	±11.1 cm	±18.8 cm
100 m	±18.8 cm	±44.4 cm	±75 cm
200 m	±75 cm	±178 cm	±300 cm
300 m	±169 cm	±400 cm	±675 cm

Depth precision is range-dependent and derived from the disparity error according to $dz = \frac{z^2}{fB}\times\text{pixel error}$, where f is the focal length in pixels, B is the baseline length, and z is the depth to the object. Values are quoted for the baseline shown in each column heading; at a 0.5-m baseline the error at a given range is twice the 1-m value.

Lateral Resolution

Range	30° FOV	65° FOV	135° FOV
10 m	0.2 cm	0.4 cm	0.8 cm
20 m	0.4 cm	0.9 cm	1.5 cm

30 m	0.6 cm	1.3 cm	2.3 cm
50 m	0.9 cm	2.2 cm	3.8 cm
100 m	1.9 cm	4.4 cm	7.5 cm
200 m	3.8 cm	8.9 cm	15.0 cm
300 m	5.6 cm	13.3 cm	22.5 cm
500 m	9.4 cm	22.2 cm	37.5 cm
1000 m	18.8 cm	44.4 cm	75.0 cm

Minimum Detectable Object Size (Tire on Road)

	30° FOV TP 50%	30° FOV TP 80%	30° FOV TP 90%	65° FOV TP 50%	65° FOV TP 80%	65° FOV TP 90%	135° FOV TP 50%	135° FOV TP 80%	135° FOV TP 90%
10 m	1 cm	1 cm	2 cm	2 cm	3 cm	4 cm	4 cm	5 cm	8 cm
20 m	2 cm	3 cm	4 cm	4 cm	6 cm	9 cm	8 cm	11 cm	15 cm
30 m	3 cm	4 cm	6 cm	7 cm	9 cm	13 cm	11 cm	16 cm	23 cm
50 m	5 cm	7 cm	9 cm	11 cm	16 cm	22 cm	19 cm	26 cm	38 cm
100 m	9 cm	13 cm	19 cm	22 cm	31 cm	44 cm	38 cm	53 cm	75 cm
150 m	14 cm	20 cm	28 cm	33 cm	47 cm	67 cm	56 cm	79 cm	113 cm
200 m	19 cm	26 cm	38 cm	44 cm	62 cm	89 cm	75 cm	105 cm	150 cm
300 m	28 cm	39 cm	56 cm	67 cm	93 cm	133 cm	113 cm	158 cm	225 cm

Minimum detectable object size of a tire on a road using 1-m baseline and GridDetect. GridDetect uses a particle filter approach and is a recursive filter like a Kalman filter so that the tracker state at frame "t" has all the accumulated information up to that frame. For practical purposes, it can be thought to integrate over approximately three frames. The ranges corresponding to true positive (TP) detection probabilities of 50, 80, and 90% are reported for a tire on a road. The TP detection range increases with higher contrast objects and depends on the number of pixels on the target, with 50% corresponding to 5 x 5 pixels, 80% corresponding to 7 x 7 pixels, and 90% corresponding to 10 x 10 pixels.

The minimum detectable object size with high confidence is 7 pixels wide. According to the table, the thinnest object at 100-m range is 13-cm wide using the 30° FOV lenses.

The smallest height object at 150 meters is 7 pixels high, or 26 cm, using 30° FOV lenses (see table for the minimum detectable object size).

Calibration

Hammerhead applies continuous per-frame online calibration to maintain stereo alignment under vibration, temperature change, and mechanical drift. Hammerhead also offers a factory calibration routine that can be run at the factory or whenever there is a large uncertainty of the camera extrinsic parameters. Extrinsic parameters are automatically calibrated; intrinsic parameters are currently not calibrated.

Factory Calibration

Parameter	Value
Run Time	30 seconds
Maximum Relative Angular Search Range	3°
Absolute Range Calibration	Included

Online Calibration

Parameter	30° FOV	65° FOV	135° FOV
Update Rate	Every frame	Every frame	Every frame
Max Angular Search Range per Frame	Up to 0.05°	Up to 0.125°	Up to 0.2°
Vibration Bandwidth	∞ Hz	∞ Hz	∞ Hz

For cars, the vibration bandwidth exceeds the Nyquist rate of the camera. For example, engine vibrations may be between 100-300 Hz, which far exceed the standard video frame rates of 10, 15, 20,

30, and 60 Hz. Therefore, calibration every frame is required for calibration because it is not possible to interpolate the extrinsic camera parameters between multiple frames.

Although our calibration can handle any perturbation speed, the captured images become blurred with excessive vibration amplitude, and blurring gradually degrades stereo matching performance. In practice, with short camera exposure time with respect to the angular perturbation rate, the blurring effect is small, and the vibration is negligible and can largely be disregarded.

Mechanical, Electrical, and Environmental Specifications

Stereo Camera

Parameter	Value
Bar Length	0.5 m, 1 m (or custom)
Power Consumption per Camera	3.1 W
Compliance	CE, FCC, RoHS, REACH, WEEE
Storage Temperature	-30 to 60°C
Operating Temperature	-20 to 55°C ambient
Humidity	20% ~ 80%, relative, non-condensing
Shock and Vibration	DIN EN 60068-2-27, 60068-2-64, 60068-2-6
Industrial EMC Immunity	DIN EN 61000-6-2
Ingress Protection	IP67
Hermetically Sealed	No
M12-to-RJ45 Cable Length	15 m (two cables from stereo camera to the PoE switch)

Computer

Parameter	Value
Processor	NVIDIA Jetson Orin Nano 8GB
GPU	1024-core NVIDIA Ampere architecture GPU with 32 tensor cores
CPU	6-core Arm Cortex-A78AE v8.2 64-bit
AI Performance	67 TOPS (INT8)
Memory	8 GB 128-bit LPDDR5, 102 GB/s
Storage	NVMe SSD (M.2 Key M)
Camera Interface	USB-to-Ethernet adapter, 2.5 GbE (USB-A port)
Host Interface	USB-to-Ethernet adapter, 2.5 GbE (USB-C port), static IP 10.10.1.10
Display Output	DisplayPort
Power Mode	MAXN SUPER, fan at maximum
Module Power	7 W to 25 W
DC Power Input Range	9 VDC to 20 VDC (19 VDC supply recommended)
Power Connector	5.5 × 2.5 mm DC barrel jack

Weight

Item	Weight
Stereo camera (1-m bar)	0.89 kg
Jetson Orin Nano computer and power supply	0.45 kg
5-port 2.5G PoE switch	0.9 kg
Two M12-to-RJ45 ethernet cables (15 m)	1.34 kg
Shipping box (complete kit)	~10 kg Varies depending on bar length and selected components.

Shipping box dimensions: 48”x17”x12”

INSTALLATION

Mounting Configurations

Cameras mount to standard T-slot aluminum, so you can easily use off-the-shelf 80/20 hardware. Full mounting dimensions are available in the CAD Drawing,.

NODAR SDK

Licensing grants a non-exclusive, worldwide, perpetual right to modify and deploy these designs within your own hardware products. Refer to the Reference Design License Term Sheet for details.

The SDK includes example code for interfacing with the HDK using ROS2 and ZMQ. Full documentation is available from the HDK Communication documentation and the SDK documentation in our GitHub repository.

ORDERING

Ordering Information

Part Number Structure

NDR-HDK-2.0-xxx-yy[-N]

- xxx = 50 for 50-cm baseline | xxx = 100 for 100-cm baseline | xxx = U for an untethered system
- Append X to xxx for a bar-mounted system (50X, 100X) | no letter indicates an enclosed system
- yy = 30 for 30° FOV | yy = 65 for 65° FOV | yy = 135 for 135° FOV
- Append -N to include the Jetson Orin Nano (e.g., NDR-HDK-2.0-100-65-N)

Example Part Numbers

Part Number	Description
NDR-HDK-2.0-100-30	Hammerhead Development Kit v2.0, 1 m baseline, 30° FOV. Sensor head only.
NDR-HDK-2.0-100-65	Hammerhead Development Kit v2.0, 1 m baseline, 65° FOV. Sensor head only.
NDR-HDK-2.0-100X-65	Hammerhead Development Kit v2.0, 1 m baseline, 65° FOV, bar-mounted. Sensor head only.
NDR-HDK-2.0-100-65-N	Hammerhead Development Kit v2.0, 1 m baseline, 65° FOV, with Jetson Orin Nano computer.
NDR-HDK-2.0-U-65-N	Hammerhead Development Kit v2.0, untethered cameras, 65° FOV, with Jetson Orin Nano computer.
NDR-HDK-2.0-N	Jetson Orin Nano computer with Hammerhead software. No stereo camera.
NDR-HW-REF-2.0	Hardware reference design with perpetual, worldwide license

Bill of Materials

NDR-HDK-2.0-xxx-yy

#	Description	Qty
1	Stereo camera, IP67, 5.4 MP	1
2	M12-to-RJ45 CAT-6a ethernet cable, 15-m length	2
3	Quick start card	1

NDR-HDK-2.0-xxx-yy-N

#	Description	Qty
1	Stereo camera, IP67, 5.4 MP	1
2	M12-to-RJ45 CAT-6a ethernet cable, 15-m length	2
3	Quick start card	1
4	NVIDIA Jetson Orin Nano computer with Hammerhead software	1
5	Orin Nano power supply	1
6	5-port 2.5G PoE switch with power supply	1
7	USB-A to RJ45 2.5G ethernet adapter (cameras)	1
8	USB-C to RJ45 2.5G ethernet adapter (data out)	1
9	Ethernet cable	2

About NODAR

NODAR develops ultra-wide baseline stereo vision software for autonomous vehicles, robotics, and industrial automation. The Hammerhead platform is proven across automotive and industrial deployments and is the foundation of the HDK development system.

Website	nodarsensor.com
Technical documentation	docs.nodarsensor.net
Integration enquiries	support@nodarsensor.com

Disclaimer