

The Intel logo, consisting of the word "intel" in a lowercase, white, sans-serif font with a registered trademark symbol.

intel®

The title for the Intel RealSense presentation, with "Intel® RealSense™" in orange and "Introduction to Depth Vision and Facial Authentication" in white.

Intel® RealSense™
Introduction to Depth Vision
and Facial Authentication

The name of the speaker, Miro Mlejnek, in white text.

Miro Mlejnek

Intel® RealSense™ Introduction

Depth Vision and Facial Authentication

March, 2021



intel
REALSENSE™

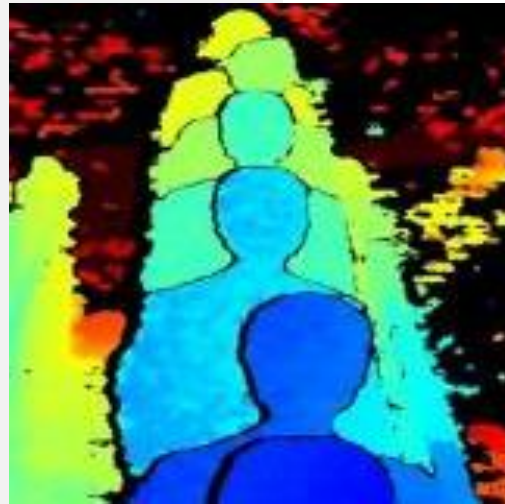
The background features a large, faint, circular logo for Intel RealSense. The logo consists of concentric circles and segments, resembling a camera lens or sensor array, with a bright light flare at the top right. The text is centered within a dark blue rectangular area.

Intel[®] RealSense[™] Technologies
Enable Your Application to See,
Understand, Interact with, and
Learn from Its Environment

Why 3D and Depth Are Important



2D Color image showing an optical illusion



Depth image shows individual objects and their position

3D depth cameras provide information that 2D cameras are unable to deliver without extensive AI and modeling support.

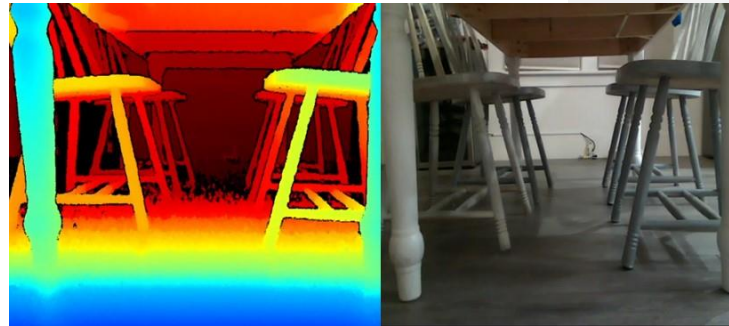
Depth cameras provide real-time depth and RGB information about every point or pixel. This provides a device with human-like vision, enabling movement or scene understanding in any environment.

Faux color represents range to object (red=far, blue=near)

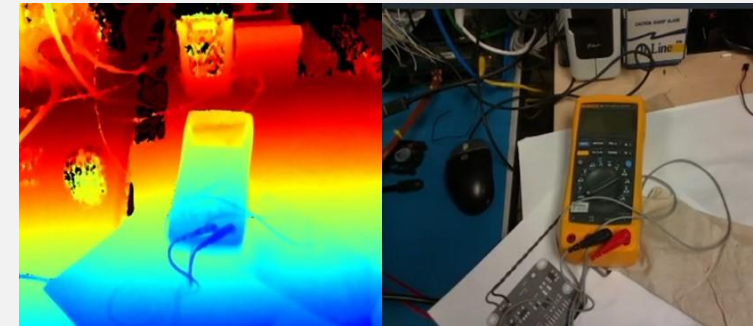
Where Depth Data Provides Advantage

Depth data communicates distance, enabling:

- Accurate measurements of objects
- Collision avoidance for robots and drones
- Better inference from more data, resulting in improved machine learning
- Easy digital twin creation
- Reduced compute and time requirements with on board vision processor
- Highly accurate facial recognition and authentication



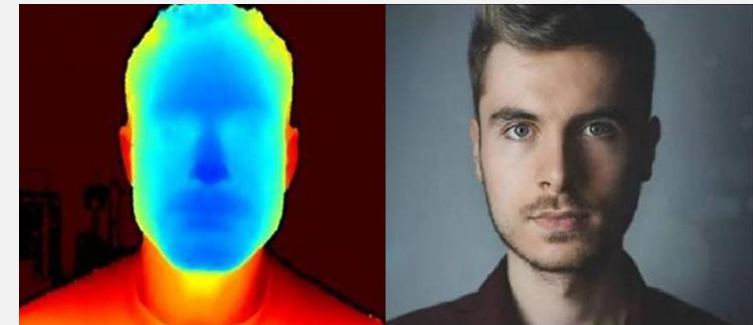
Obstacle Detection & Collision Avoidance



Object Recognition



Size and Volume – e.g., Object Measurement



Facial Authentication

Faux color represents range to object (red=far, blue=near)

3D Sensing Brings Value to Variety of Markets



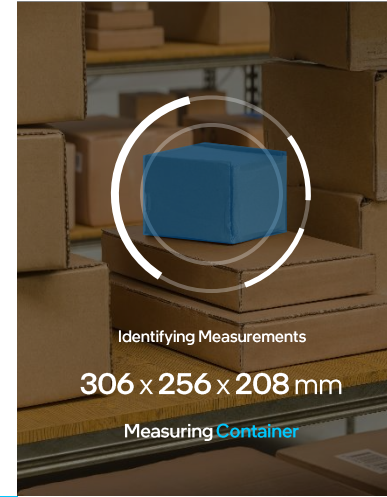
Facial Authentication



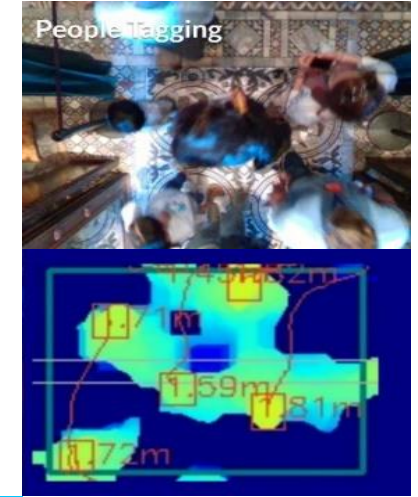
Robotics



Scanning



Measurement and Logistics

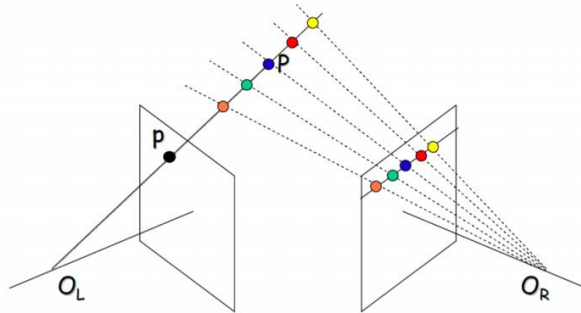


Recognition and Interaction

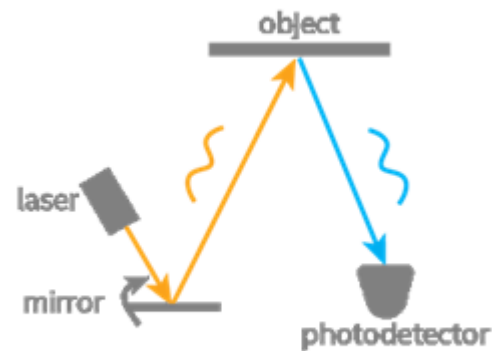
Utilizing a Range of Sensor Technologies

Intel® RealSense™ cameras utilize a variety of sensor technologies to create vision-based solutions that work in ways like human vision.

Depth

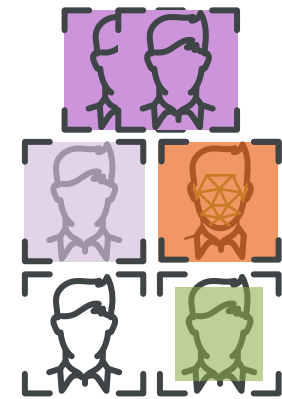


Stereo
D400 Family



LiDAR
L515

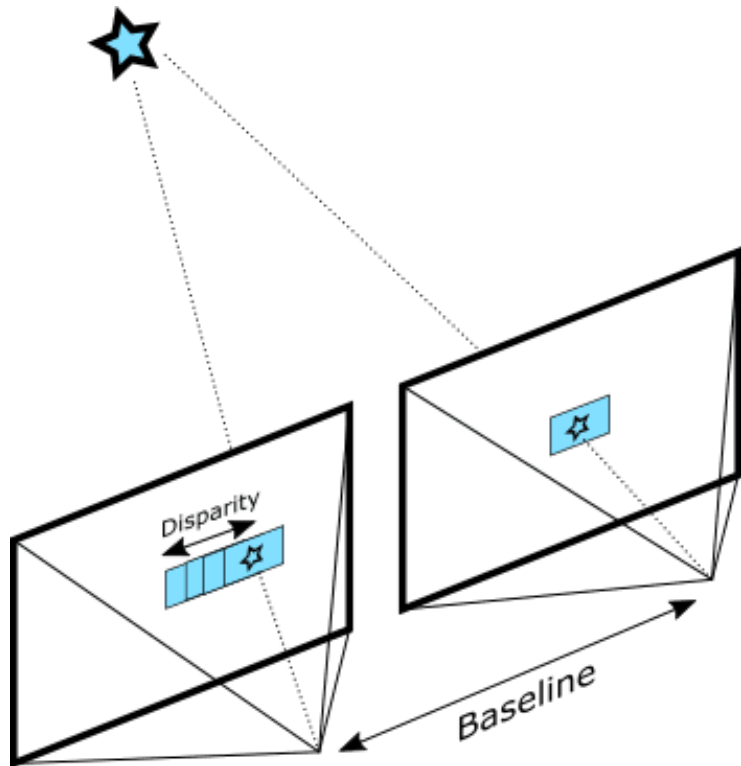
Facial Authentication



Multiple Sensor
Technologies
F400 Family

Stereoscopic Vision

Depth from Stereo is a classic computer vision algorithm inspired by the human binocular vision system. It relies on two parallel view-ports and calculates depth by estimating disparities between matching key-points in the left and right images:



▪ Most naive implementation of this idea is the SSD (Sum of Squared Differences) block-matching algorithm:

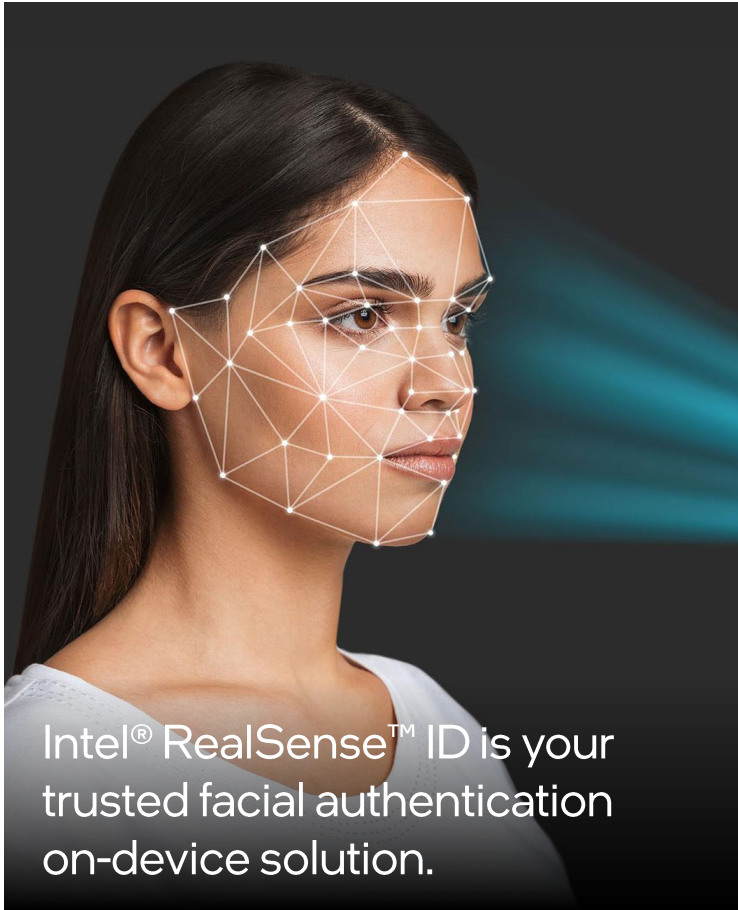
```
1 import numpy
2
3 fx = 942.8 # lense focal length
4 baseline = 54.8 # distance in mm between the two cameras
5 disparities = 64 # num of disparities to consider
6 block = 15 # block size to match
7 units = 0.001 # depth units
8
9 for i in xrange(block, left.shape[0] - block - 1):
10     for j in xrange(block + disparities, left.shape[1] - block - 1):
11         ssd = numpy.empty([disparities, 1])
12
13         # calc SSD at all possible disparities
14         l = left[(i - block):(i + block), (j - block):(j + block)]
15         for d in xrange(0, disparities):
16             r = right[(i - block):(i + block), (j - d - block):(j - d + block)]
17             ssd[d] = numpy.sum((l[:, :] - r[:, :])**2)
18
19         # select the best match
20         disparity[i, j] = numpy.argmin(ssd)
21
22 # Convert disparity to depth
23 depth = np.zeros(shape=left.shape).astype(float)
24 depth[disparity > 0] = (fx * baseline) / (units * disparity[disparity > 0])
```


L515 Scanning Technology



Facial Authentication

Challenges and solutions



Typical Challenges

Privacy and Security

Spoofing

Accuracy

Lighting

User on-boarding

User Experience

Appearance Changes

Different Heights

Intel® RealSense™ Technology Delivers

On-device face authentication and Secure Element

Active depth sensor with anti-spoofing technology: SAR <0.10%

Specialized neural network, top-tier NIST results, 1:M FAR, 99.71% TAR

Multiple sensors, built-in illuminator for bright sunlight to darkness

Easy enrollment and no network setup needed

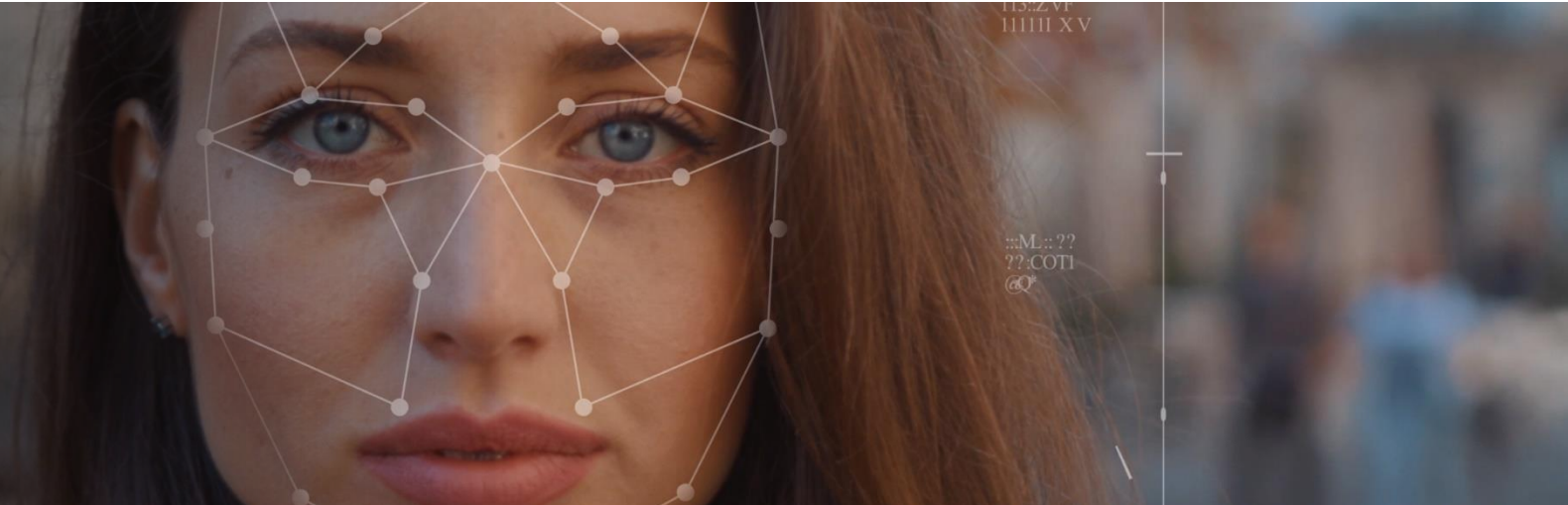
RGB preview, understands intent and unlocks in <1s

Adapts to changes over time, with or without facial hair, glasses and accessories

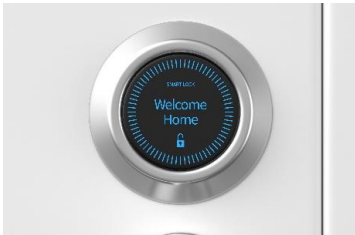
Wide FOV: children to tall adults

Facial Authentication

Securely unlock homes and businesses with a single glance. Intel® RealSense™ ID offers all-in-one facial authentication that's secure, accurate, and fast.



Smart Lock



POS



Kiosk



ATM



Gate Access Control



Rapid Authentication with Privacy Built-in

EASY ENROLLMENT

FAST AUTHENTICATION



SECURE



ANTI-SPOOFING



IDENTIFICATION



No photo stored

Less than a second

The slide features a dark blue background with a complex, futuristic graphic on the left side. This graphic consists of multiple overlapping circular patterns, some resembling gears or circuitry, with various lines and dots. A small cluster of three squares (two light blue, one dark blue) is positioned near the top of the graphic. The main title is centered in a white, sans-serif font. The background is split vertically, with a darker blue on the left and a lighter blue on the right.

Intel[®] RealSense[™] Hardware & Software Offerings

Intel® RealSense™ Hardware Portfolio

LiDAR*

Accuracy over Range



L515

Indoor LiDAR Camera

Great accuracy throughout entire range
(25cm-9m)

Stereo*

Indoor/Outdoor/Multiple



D455 (IMU)

.6m-6m (Ideal Range)



D415

.5m-3m (Ideal Range)



D435

.3m-3m (Ideal Range)



D435i (IMU)

.3m-3m (Ideal Range)



D410



D415



D430



**ASIC Board
V1, V2, V3**



D450

Facial Authentication**

On-board Facial Authentication

FA Camera & Module



F455



F450

Tracking



T265

Onboard VSLAM
Intel® Movidius™ Myriad™
2 VPU



T261

* Supported by LibRealSense Open - source SDK **Supported by Intel RealSense ID SDK




















Intel® RealSense™ Depth Family Offerings

	D415	D435/D435i	D455	L515
Typical Use Case	Collision avoidance Recognition and Interaction Scanning	Collision avoidance Recognition and Interaction Scanning	Collision avoidance Recognition and Interaction Scanning	Pick and Place Recognition and Interaction Logistics Scanning
Value	Best Priced Stereo Camera	WFOV Stereo Camera with or without IMU	Longer Range Stereo Camera	Best Edge Fidelity
Ideal Range <small>(Stereo cameras can see further but > Distance = accuracy worsens geometrically)</small>	.5m to 3m	.3m to 3m	.6m to 6m	.25m to 9m ³ <small>(Range effected by reflectivity)</small>
Depth Accuracy²	<2% at 2m	<2% at 2m	<2% at 4m	~5mm to ~14mm thru 9m
Min Z @ Max Resolution	Min Z ~45cm	Min Z ~28cm	Min Z ~52cm	Min Z ~25cm
Environment	Indoor & Outdoor	Indoor & Outdoor	Indoor & Outdoor	Indoor
Max Depth Resolution	1280x720 @ 30fps 848x480 @ 90fps	1280x720 @ 30fps 848x480 @ 90fps	1280x720 @ 30fps 848x480 @ 90fps	1024x768 @ 30fps
Depth FOV HD/Shutter¹	64°x41°/Rolling	86°x57°/Global	86°x57°/Global	70°x55°
RGB/Shutter¹	2MP/64°x41°/Rolling	2MP/64°x41°/Rolling	1MP/90°x65°/Global	2MP/Rolling
Product Dimensions (mm)	99x23x20	90x25x25	124x29x26	61diameter x 26
IMU	NO	NO (D435i YES)	YES	YES

¹FOV is measured +/-3° of stated value; ²Z-accuracy as measured as out of the factory; ³9m at 10% ROI with 95% target reflectivity;

Intel® RealSense™ SDK 2.0

For all Intel® RealSense™ Depth and Tracking Products

Intel® RealSense™ SDK 2.0	Supported Platforms	Programming Languages	Available Wrappers	
<p>Open-source cross-platform library for all Intel® RealSense™ cameras and modules</p> <p>Download from github</p> 	   	   	         	

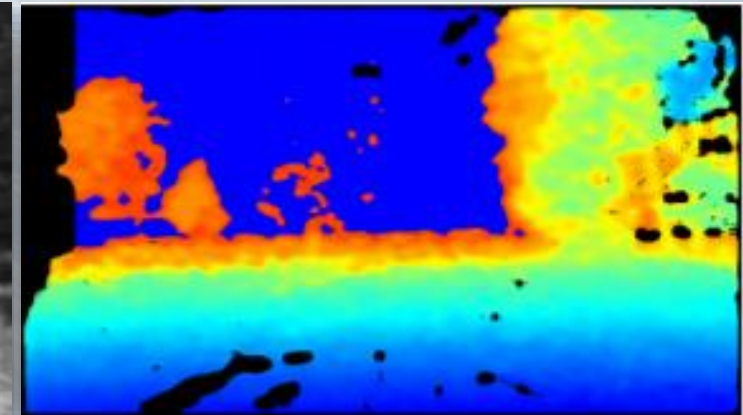
In addition to the platforms above we also have installation guides for Jetson TX2, Raspberry Pi 3.

Code examples

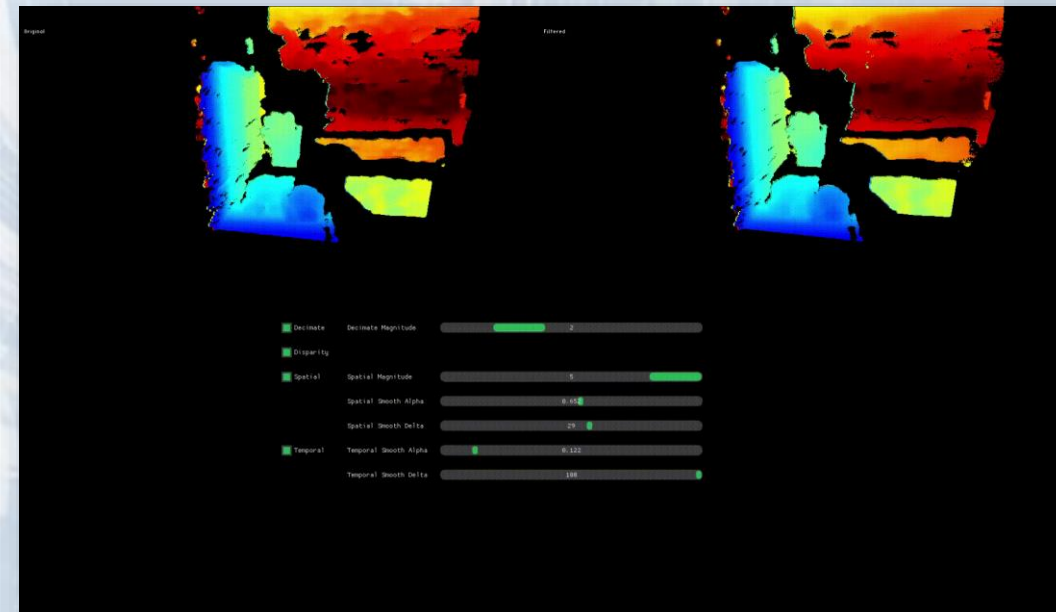
Object recognition with OpenCV or OpenVINO



Collision avoidance outdoor drones



Post processing



Intel® RealSense™ Self-Calibration

Providing simple calibration tuning of our stereo cameras

Intel® RealSense™ Self-Calibration



Health-Check



Self-Calibration



TARE



Flatten



Recover (restore & revert)

Features

On-Chip	Cross-Platform (any OS, SOC)
Fast (<2sec)	Low Bandwidth
Low Power	USB2 & USB3
Target-less	

Intel® RealSense™ ID SDK

For F450 and F455 products

Intel® RealSense™ ID SDK

Open-source cross-platform library for all Intel® RealSense™ ID peripherals and modules



Download from github
[RealSense ID github](#)

Supported Platforms



Programming Languages

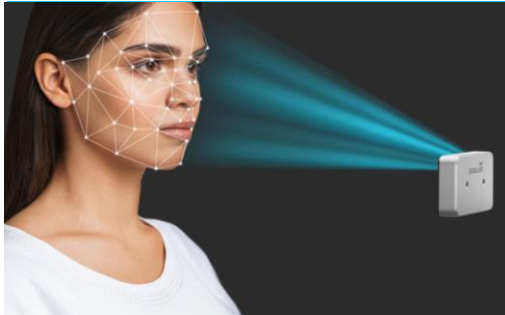


API Support

Enrollment
Authenticate
User Management
UX/UI
Device Management
Firmware Updates

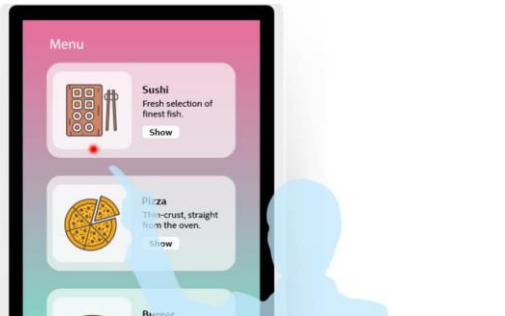
* Coming soon

Intel® RealSense™ Software Technologies



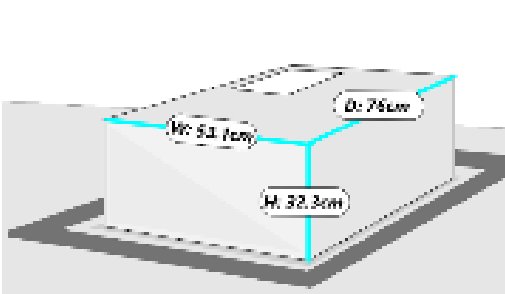
Intel® RealSense™ ID

- Facial authentication = facial recognition+ anti-spoofing
- Highly accurate solution for 3D and 2D IR
- Works well indoors or outdoors or in low light conditions
- Low latency and low power



Intel® RealSense™ Touchless Control Software

- Seamlessly converts a touch interaction to a touchless
- Easy to install and requires no change to existing user interfaces or core software.
- Versatile enough to support new and existing installations like kiosks and digital signs



















Intel® RealSense™ DIM Weight Software

- Highly accurate solution using our LiDAR technology
- Free trial available
- Legal for trade ready
- Easy to use SDK with sample application

Computer Vision Libraries photo source: FramosAI.co

3rd Party Software for Intel® RealSense™

3D Scanning	Background Segmentation	Eye Tracking	Gesture Recognition Digital Signage
  		 	
Other Cases	People Tracking	Skeletal Tracking	Volumetric Capture
   		  	

The slide features a dark blue background with a complex, futuristic pattern of white and light blue lines, circles, and gears, suggesting a high-tech or artificial intelligence theme. A semi-transparent dark blue rectangular box is centered on the slide, containing the main title text in white. The text is arranged in two lines: the first line reads 'Intel® RealSense™' and the second line reads 'Product Offerings'.

Intel® RealSense™ Product Offerings

Intel® RealSense™ ID Solution F455/F450



F455 Peripheral



F450 Module

- Wide V-FOV: 56 x 78
- Facial Authentication up to 1 m
- Intel RealSense ID software on embedded SOC
- Independent from host platform

Plug and Play Facial Authentication Module

The Intel® RealSense™ ID is a plug and play device that enables facial authentication out of the box.

With fast and easy integration, it can be used for smart locks, point of sales (POS), kiosks, ATMs, or access control. It can support 1:1M FAR, 99.7% TAR and SAR < 0.1%.

We designed the Intel® RealSense™ ID Solution to work well both indoors and outdoors, with an IR LED Illuminator.

Intel® RealSense™ Depth Camera D415



D415 Module

- Active stereo
- Rolling shutter
- 64° x 41° FOV

Affordable Accuracy

The Intel® RealSense™ Depth Camera D415 and the Intel RealSense depth module D410/D415 offer high-value precision and accuracy across a multitude of use cases at low cost.

With a focused field of view, the D415 camera delivers higher-quality depth per degree. The modules' Intel® RealSense™ vision processor D4 does all depth calculations onboard, making this a low power, platform-agnostic device.

The D415 is ideal for use cases such as robotics, scanning, recognition and interaction.

Intel® RealSense™ Depth Camera D435



D430 Module

- Active stereo
- Global shutter
- 86° x 57° FOV

Broadest Vision

The Intel® RealSense™ Depth Camera D435 features our widest field of view, along with a global shutter for high-speed depth applications. Its capabilities are available in the D420 and D430 modules as well.

The Intel® RealSense™ vision processor D4 does all depth calculations onboard, making this a low power, platform-agnostic device.

The D435 is ideal for use cases such as fast-moving robotics, scanning, recognition and interaction.

Intel® RealSense™ Depth Camera D435i



D430 Module

- Active stereo
- Global shutter
- 86° x 57° FOV
- Integrated BMI055 IMU

Makes New Sense

The Intel® RealSense™ Depth Camera D435i adds an inertial measurement unit (IMU) to the wide field of view and global shutter sensor of our cutting-edge D435 stereo depth camera. Adding an IMU allows your application to refine its depth awareness in any situation where the camera moves.

With its IMU, the D435i provides position information along with depth for use cases such as robotics, scanning, recognition and interaction

The D435i capabilities are available in the D430 module as well.

Intel® RealSense™ Depth Camera D455



D450 Module

- Active stereo
- Global shutter
- <2% at 4 m Z-Error
- 86° x 57° FOV
- Integrated BMI055 IMU

Twice the Performance. All the Versatility.

The Intel® RealSense™ Depth Camera D455 improves on the design of the D435i with several enhancements. It extends the distance between the depth sensors to 95 mm, improving the depth Z-error* to less than 2% at 4m. To improve the correspondence between the depth and RGB images, the RGB sensor includes a global shutter and is matched to the depth FOV with both having an 86° field of view.

The D455's longer range and is ideal for robotics, scanning, recognition and interaction. For embedded applications, the same capabilities are available in the D450 module.

*Z-accuracy as measured as out of the factory

Intel® RealSense™ LiDAR Camera L515



- Miniaturized LiDAR
- 1024x768 depth resolution
- 70° x 55° FOV

The World's Smallest Hi-res LiDAR Camera

The Intel® RealSense™ LiDAR Camera L515 is the industry's first low power, small form factor LiDAR-based depth camera. The L515 is perfect for applications requiring depth data at high resolution and high accuracy.

It uses Intel's proprietary 2D MEMS system to scan a laser beam across the entire field of view and features a ~16 mm, 0.15% depth standard deviation and accuracy at 9 m.

The L515 is the right fit for use cases where scanning accuracy is paramount and lighting is controlled. Examples include box measurement, object and room scanning, or any use where scanning at a further distance is required.

Intel® RealSense™ Tracking Camera T265



T261 Module

- Onboard SLAM
- Two fisheye cameras 170° FOV
- Intel® Movidius™ Myriad™ 2 VPU
- Operates at less than 1.5

Find Your Place in the World

The T265 is the first stand-alone inside-out tracking device in the world.

It runs Intel's Simultaneous Localization and Mapping (SLAM) algorithms on the integrated Myriad 2 VPU for platform-agnostic, low power, 6DoF tracking, and is available as the T261 module.

The T265 is ideal for use cases such as indoor and outdoor robotics, drones, and augmented reality.

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