Milesight

PEOPLE COUNTING

AI ToF People Counting Sensor

VS133

Accurate and Anonymous People Counting
by AI & ToF Technology

What Is People Counting

Utilizing electronic devices, people counting is a way to measure the number of people that pass through a certain passage or entrance or that stay in a given area. There are two main people counting categories regional people counting and line crossing people counting to understand how many people are in specific areas at any time. **Regional people counting**, as its name implies, counts the number of people in a region for overall data. Wi-Fi and Bluetooth Tracking, Thermal Imaging Technology, Radar, Camera Imaging and 3D Binocular Vision are common technologies for regional people counting. **Line crossing people counting**, as the name implies, counts the number of people that cross the predefined line. Mainly applied in entrances or corridors, it has a narrower detection range. The common technologies for line crossing people counting are Infrared Break Beam, Camera Imaging, 3D Binocular Vision and ToF plus Bi-lens Camera Imaging.

Milesight People Counting Sensor Accurately and Anonymously Counts

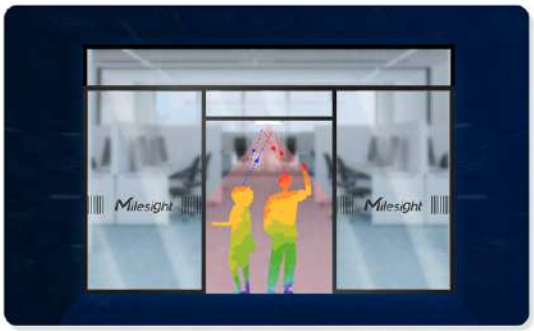
Applied the advanced onboard AI algorithm and 2nd generation ToF technology, the AI ToF People Counting Sensor reaches industry-leading 99.8% accuracy and 100% anonymous detection which perfectly meet GDPR. With reliable counting of people in both directions simultaneously, it gets precise and valuable statistics to realize informed management and data-driven decisions making.

On-Board AI Algorithm

It is a next-generation people counting sensor with an embedded AI algorithm that allows to filter unnecessary counts and distinguish different crowds, greatly improving accuracy and scenario adaptation for optimal performance.

2nd Generation ToF

Based on the favorable ToF (Time of Flight) technology which features high accuracy and anonymous protection, the sensor creatively adapts the upgraded technology with stronger performances, higher precision, and better scenario adaptability to boost application.



Industry-Leading 99.8% Accuracy

With more robust ToF technology and people counting algorithm, the sensor can better filter non-object targets, lessen undetected probability, reduce dependence on installation height, and improve light anti-interference performance, contributing to an unparalleled 99.8% accuracy.

100% Anonymous Detection

The sensor is compliant with GDPR. It only gets in-depth images without involving personally identifiable information based on ToF technology, which protection at source.

Superior Recognition Features

More than just the reliable counting of people in both directions simultaneously, the smart sensor also gives direct access to recognize specific categories of individuals including staff detection and adults/children differentiation, realizing precise people counting to optimize operational efficiency.

Great Compatibility

The alternative LoRaWAN® and Ethernet transmission helps to flexibly make informed decisions for different application fields. The strong scalable capacity based on the open APIs and MQTT(s)/HTTP brings more possibility in compatibility and customized features to unlock the potential of the premises.

No Privacy Concerns at All

Privacy is highly concerned, especially in the age of heavy information leakage. Personally identifiable information is easily captured by diversified electronic devices and the Internet. To alley the fear of information leakage, Milesight 3D ToF People Counting Sensor adopts 3D ToF technology and transmits data via LoRaWAN® protocol to 100% guarantee privacy.

2nd Generation ToF Technology

ToF forms 3D depth information through time of flight rather than capturing images which involve personally identifiable information through the lens. ToF technology eliminates privacy leakage worries ultimately.

GDPR Compliant

The General Data Protection Regulation (GDPR) is the toughest privacy and security law in the world. Though it was drafted and passed by the European Union (EU), it imposes obligations onto organizations anywhere, so long as they target or collect data related to people in the EU. With the GDPR, Europe is signaling its firm stance on data privacy and security at a time when more people are entrusting their personal data with cloud services and breaches are a daily occurrence. The Milesight 3D ToF People Counting Sensor abides by GDPR compliance considering all possible factors at design.

LoRaWAN®

LoRaWAN® is a Media Access Control (MAC) layer protocol built on top of LoRa modulation. It is a software layer that defines how devices use the LoRa hardware, for example when they transmit, and the format of messages. LoRaWAN® baud rates range from 0.3 kbps to 50 kbps. The feature makes it fit for anonymous detection. It only transmits small-size payloads (like sensor data) over long distances, which is a double assurance of anonymous detection.

Convert Numbers into Decision-Making Insights

The number of people in a specific space is under control through bi-directional line crossing people counting. With 99.8% ultra-high accuracy and 100% anonymous detection by design, the traffic of any space is precisely counted. As basic data, the statistics can be extended to unleash diversified values.

Commercial Building, People Flow Analytics

The sensor can be applied to the doorways or corridors in commercial buildings to get real-time and historical people flow statistics. The overall space capacity and usage patterns will be clear, and it can be specific to some typical areas such as meeting rooms, offices, lounges, etc., which allows for understanding the workplaces through rich data to better allocate resources, avoid unnecessary energy waste and optimize space utilization.

Retail Store, Customer Flow Analytics

The retail stores, supermarkets and shopping malls' customer flows are of great concern for business running. Centering on real-time and accumulated statistics, the operators can easily discover peak hours for the greatest sales opportunities and get conversion rates through the customer volume to have a better understanding of the business effectiveness. Furthermore, optimize staff management reasonably to fit the customers' actual needs.

HVAC System Management

Based on highly accurate people counting, the sensor offers an efficient way to precisely control the heating, ventilation and air conditioning system. The temperature should be regulated to ramp up or cool down when the people flow changes. So does the ventilation system. The smart linkage provides the spaces with thermal comfort and acceptable indoor air quality.

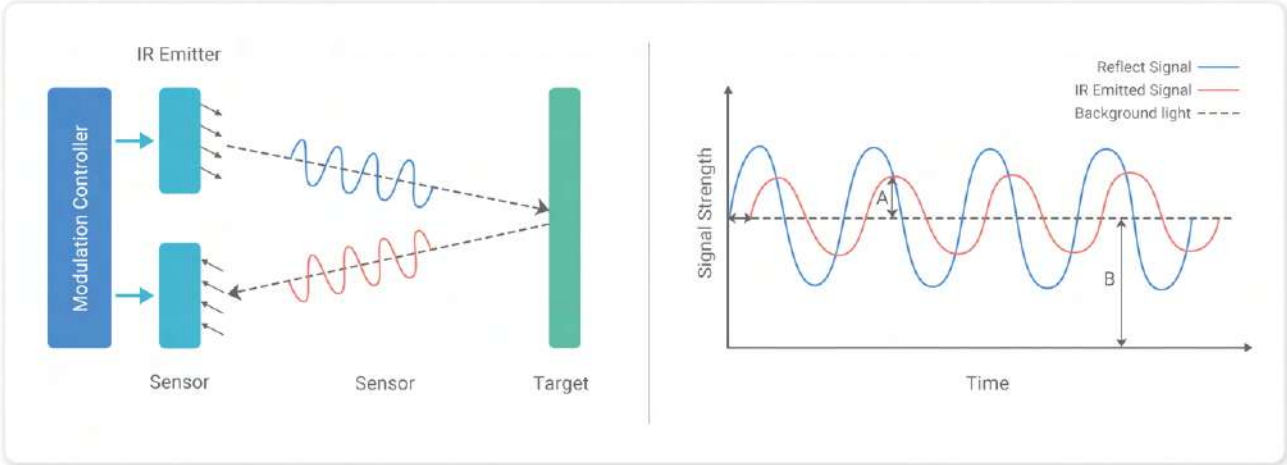
Transportation, Passenger Flow Analytics

The ToF-based sensor with an active ToF light source fits any traffic circulation environment even in low light conditions. It counts passengers getting on or off in real time to obtain statistics that will be valuable for optimizing operations. The peak hours with the largest passenger volume, the most crowded carriages, the less occupant carriages and all the other information get from the accurate people counting will be the basis to further make effective operational decisions.

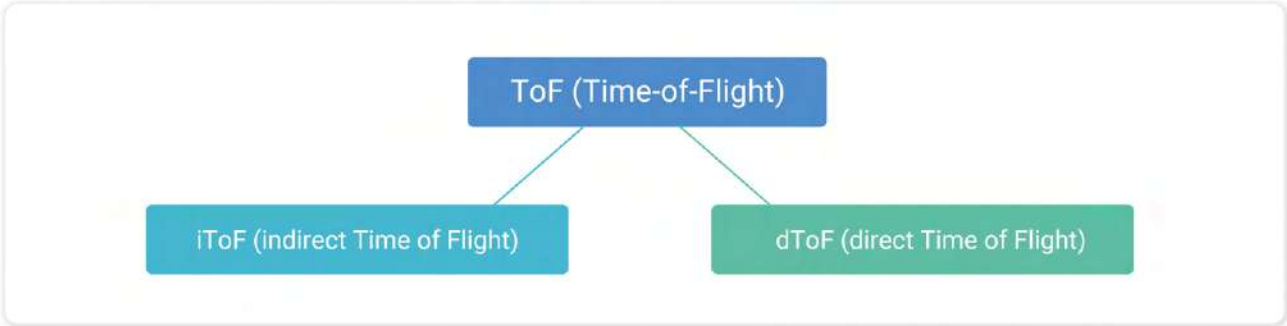
How ToF Technology Works

Three-dimensional sensing (3D Sensing) is the process of obtaining length, width, and depth information electronically and using this data to improve the interfaces between humans, devices and the world. 3D sensing technology uses near-infrared light reflection, geometric principles, photography, and advanced computing power to enable machines to "see" people and objects in a detailed, meaningful way. One of the primary categories of 3D sensing technology is known as ToF (Time-of-Flight)

ToF (Time-of-Flight) refers to emitting light at an object and measuring how long it takes to bounce back and return, then converting the time measurement into distance using the speed of light, giving the object's shape and position in its surroundings.

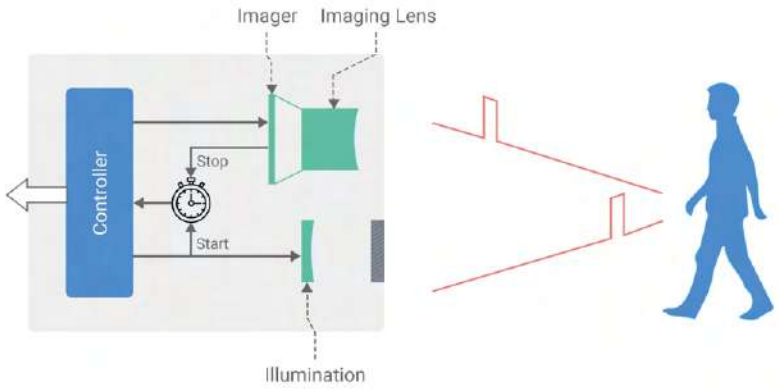


The ToF technology consists of dToF (direct Time of Flight) and iToF (indirect Time of Flight) which are distinguished by different detection methods.

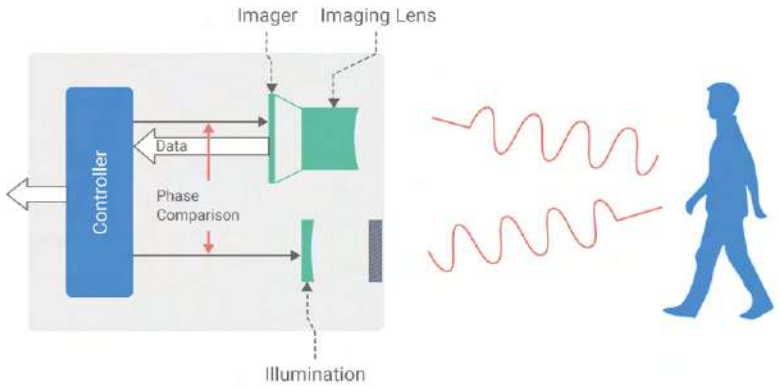


iToF and dToF Technologies

dToF The abbreviation of Direct Time-of-Flight, is a technology that directly measures the time of flight. The core components of a dToF module include a VCSEL, Single-Photon Avalanche Diode (SPAD) and Time-to-Digital Converter (TDC). SPAD is a photoelectric detection avalanche diode with single-photon detection capability, it can generate current as long as there is a weak optical signal. The VCSEL of the dToF module emits pulse waves into the scene, and the SPAD receives the pulse wave reflected from the target object. The TDC will record every flight time of receiving the optical signal, that is, the interval of emitting pulse wave and receiving pulse wave. dToF will emit and receive N times of optical signals within a single frame measuring time, and then make histogram statistics for the recorded flight time, among which the flight time with the highest frequency is used to calculate the depth of the object detected.



iToF The full name is Indirect Time-of-Flight, indirectly measures the flight time of light by the phase difference. The iToF module emits a modulated infrared signal into the scene, then receives the light signal reflected from the object detected, and calculates the phase difference between the emitted signal and the received signal according to the accumulated charge during the exposure time. It will get the depth information of the target object via the processes.

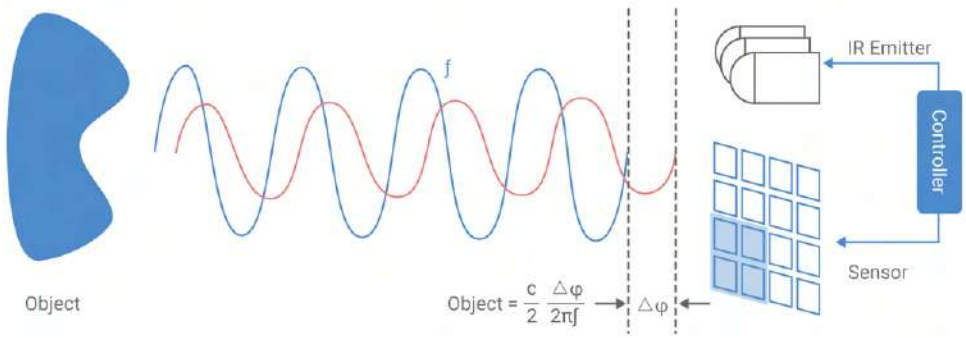


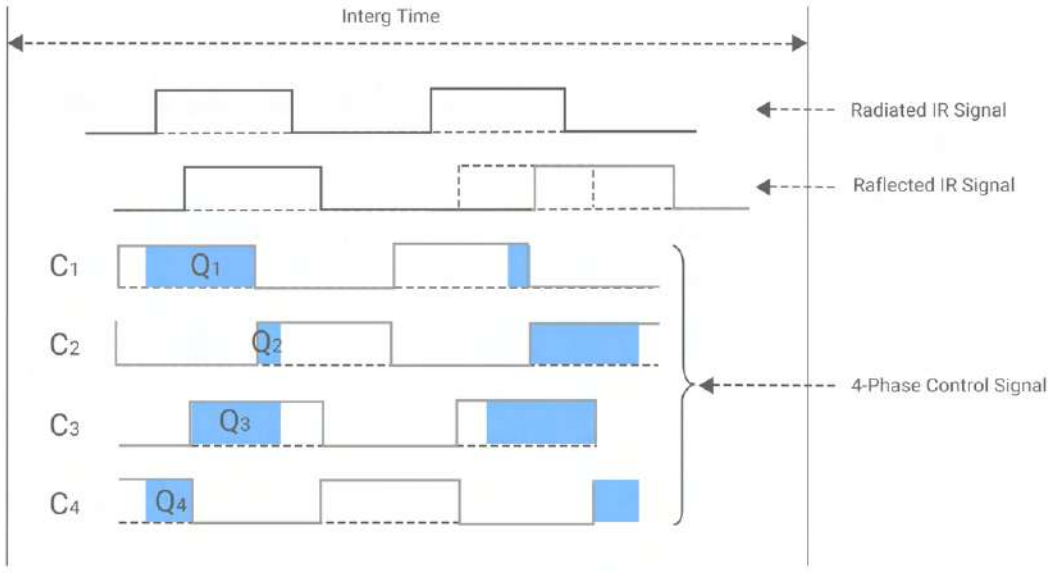
dToF technology is only used by a few manufactures like Apple not just because it lacks corresponding applications, but also because it has technical difficulty. Among them, SPAD technology is the core challenge. iToF has a high image resolution, which can reproduce more detailed information in the scene in application scenarios such as object recognition, 3D reconstruction and behavior analysis.

iToF - Indirect Time of Flight

Milesight 3D ToF People Counting Sensor VS132 is an application of Indirect Time of Flight (iToF) technology that uses the phase difference, rather than time signature, of the reflected light to measure the distance from individual points on an object. Indirect ToF technology includes a modulated light source at a set frequency. Distances are determined based on the phase difference between incoming and outgoing light. High accuracy iToF sensors perform best in short range conditions of 30 meters or less.

The core components of the iToF module include a VCSEL and an image sensor. The VCSEL emits modulated infrared light at a specific frequency. The image sensor receives the reflected light and performs photoelectric conversion within the exposure time. The data will be read after exposure and then passed to the calculation unit after getting through an analog-to-digital converter. Finally, the phase offset of each pixel will be calculated by the calculation unit. The method iToF applies to calculate the depth is usually the 4-sampling-bucket algorithm. It calculates the depth using 4 sampling signals with phase delays of 0°, 90°, 180° and 270°.





Formation principle

Advantages of ToF Technology

• Working Conditions

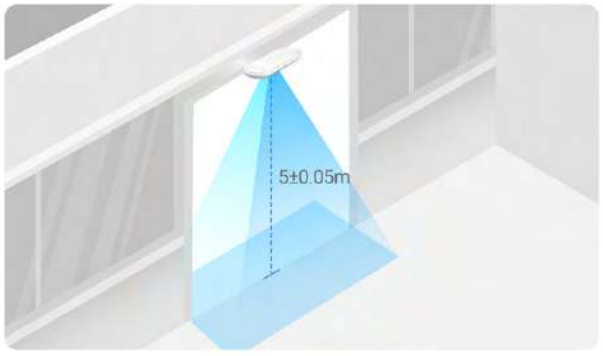
It works even in completely dark environments. As an active technique, it is able to project ToF light without relying on any external source of light to scan its surroundings like passive imaging techniques (such as stereo cameras) do.

• Processing Speed

The time-of-flight principle is based on pretty straightforward math and relatively simple algorithms, as opposed to stereoscopic cameras that require complex calibration and processing to generate the image.

• Precision

The accuracy greatly depends on the distance from the object as it is generally estimated at 1% of that value. So if an object is 5 m away, a ToF device can achieve an accuracy of about 5 cm.



• Anonymous Detection

One of the most noteworthy advantages of ToF people counting systems is that they are intrinsically GDPR compliant. Due to the relatively low spatial resolution of the sensors which produce 3D depth images, no personally identifiable information is captured.

The Commonly Used Technologies for People Counting

Regional People Counting

Wi-Fi and Bluetooth Tracking

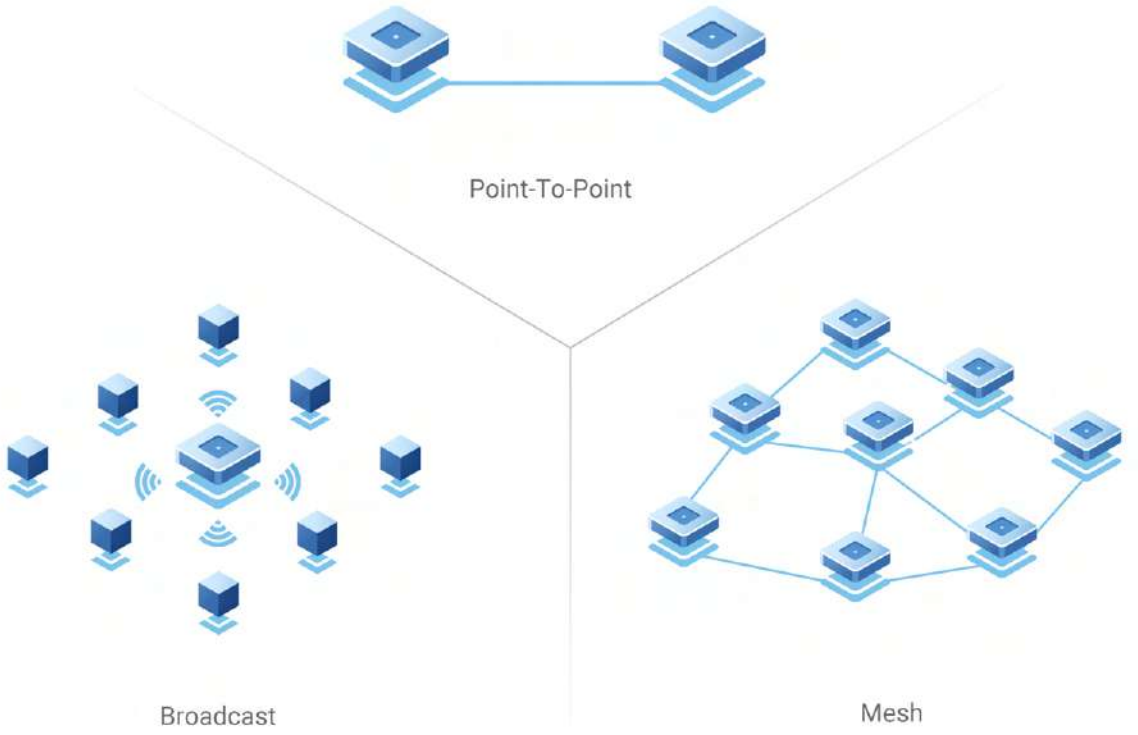
- **Bluetooth Low Energy**

The Bluetooth Low Energy (LE) radio is designed for very low-power operation. Transmitting data over 40 channels in the 2.4GHz unlicensed ISM frequency band. It supports multiple communication topologies, expanding from point-to-point to broadcast and, most recently, mesh, enabling Bluetooth technology to support the creation of reliable, large-scale device networks.

- **Wi-Fi**

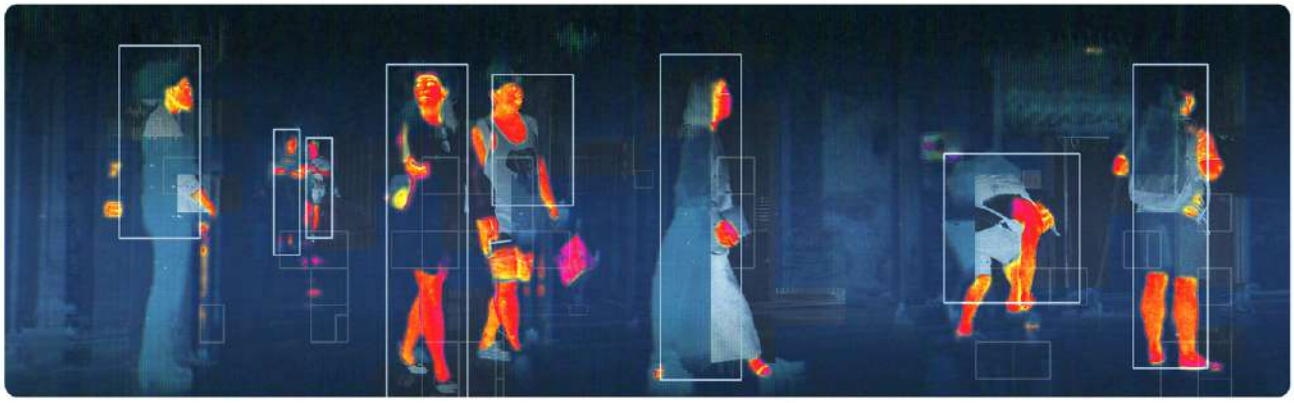
WiFi signals have been used for communication and also sensing. In most related work, RSSI values for Wi-Fi signals have been utilized for counting the number of people walking in a specific area.

Wi-Fi and Bluetooth are two familiar technologies in the market but still have obvious flaws. The accuracy is not high enough for precise people counting and wireless signals can be blocked or reflected by the human body or other obstacles. In most instances, not every person carries devices with Wi-Fi or Bluetooth, and with them enabled. It also captures personally identifiable information(PII) may lead to privacy concerns.



Thermal Imaging Technologies

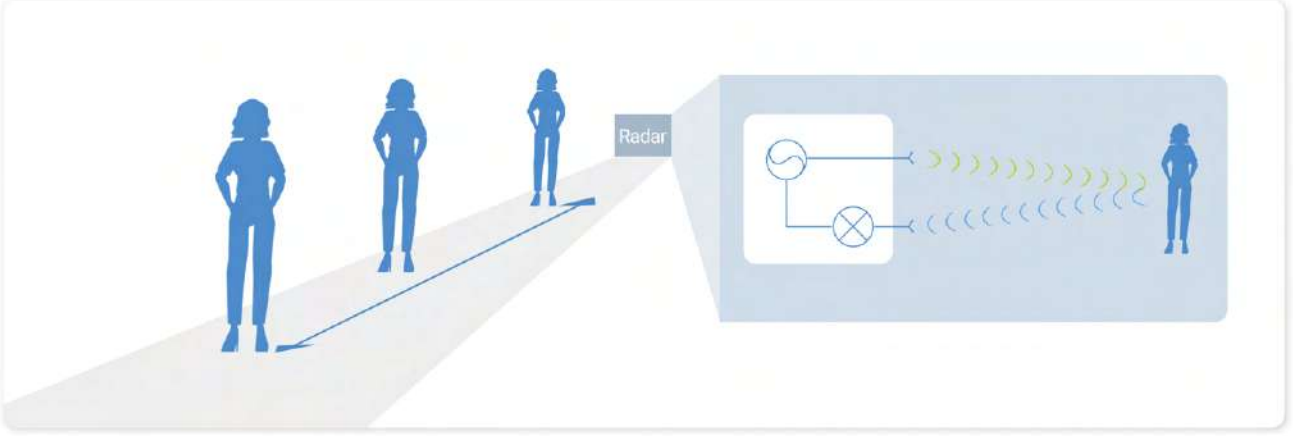
Infrared energy (heat) is a function of temperature. It is known as its heat signature is emitted by all subjects. The device detects the infrared radiation in the long-infrared range of the electromagnetic spectrum (roughly 8,000~14,000 nanometers or 8~14μm) from objects in the scene and produces images based on information about the temperature differences to know the space occupancy situation. Thermal imaging is a good way for low light detection, which doesn't count on ambient lighting environments. Overlooking the blocking of smoke, fog and haze, it can be applied in some specific environments under special weather conditions. But sunlight will be a trouble for its performance since it works by the principle of temperature. Thermal energy can be reflected by shiny surfaces and can't get through solid obstacles or even just a group of people, which will all influence the detection accuracy and results.



* Integrated with AI algorithm to realize comprehensive people counting functions.

Radar

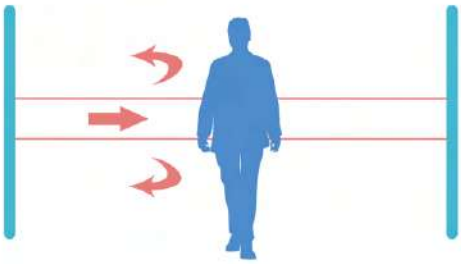
Radar, originally an acronym for radio detection and ranging, is a detection system that uses radio waves to determine the distance (ranging), angle, and radial velocity of objects relative to the site. It is an "active" sensing device in that it has its own source of illumination (a transmitter) for locating targets. It typically operates in the microwave region of the electromagnetic spectrum—measured in hertz (cycles per second), at frequencies extending from about 400 megahertz (MHz) to 40 gigahertz (GHz). mmWave, InSAR and FMCW Radar are the most commonly used radar technologies for people counting and space occupancy. You don't have to worry about privacy problems when using radars. And it reaches long distances with wide area coverage. Conversely, it can be easily influenced by the multipath effect. When detecting objects still or close, the accuracy of results decreases on account that it can not well detect static objects and near objects respectively.



Line Crossing People Counting

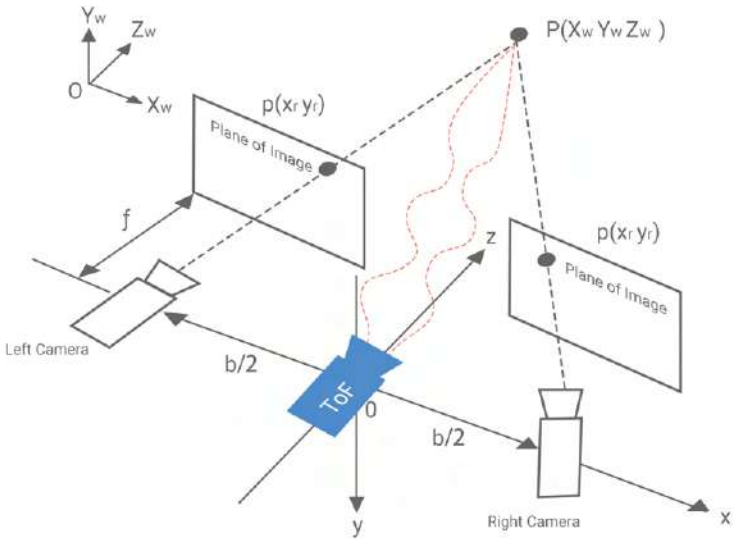
Infrared Break Beam

Infrared (IR), also called infrared light, is electromagnetic radiation (EMR) with wavelengths longer than those of visible light. It is therefore invisible to the human eye. Usually applied in the sensor for detecting objects, the infrared break beam is a kind of active infrared technology which requires both an emitter and a receiver. It works by having the emitter send out a beam of human-invisible IR light, then a receiver across the way which is sensitive to that same light. When something which is not transparent to IR passes between the two, then the 'beam is broken' and the receiver will get the information. Without relying on lighting conditions, it is able to detect objects in light and dark environments. But accuracy is easily influenced by obstacles and the number of people passing. It might just be appropriate for detecting occupancy with "yes" or "no".



Binocular Vision Plus ToF

Both ToF and Binocular Vision are the branches of 3D Vision. Binocular stereo vision is a technique that mimics the binocular vision of humans. Binocular Stereo Vision cameras have two lenses, apart from a distance of larger than 60mm (the distance varies on the basis of actual installation height), enabling each of them to capture slightly different images, which are computed by the processor to generate a depth map. ToF is a technique of calculating the distance between the camera and the object, by measuring the time it takes the projected infrared light to travel from the camera, bounced off the object's surface, and return to the sensor. As light speed is constant, by analyzing the phase shift of the emitted and returned light, the processor can calculate the distance of the object and reconstruct it. Unlike stereo vision technology, ToF is an active technique, because it actively projects light to measure distance, instead of relying on ambient light. It works well in dim light conditions. The combination of the two technology will greatly enhance the accuracy and adaptability to application environments.

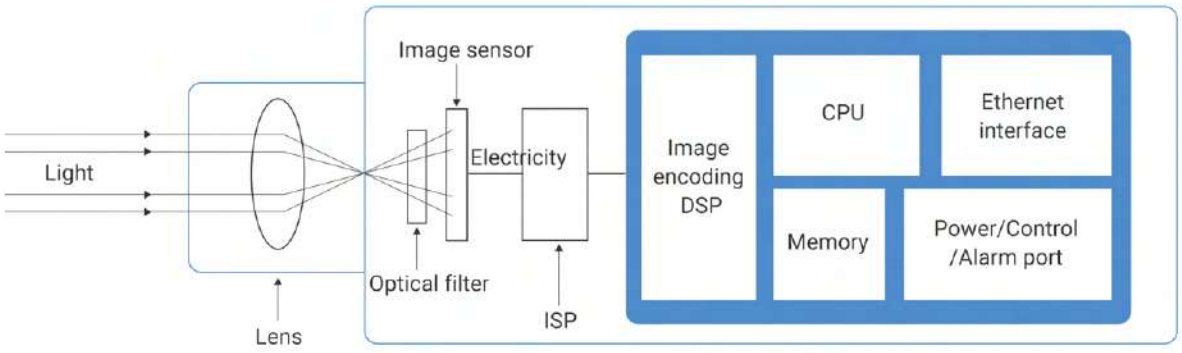


* Integrated with AI to realize comprehensive people counting functions.

Both Regional / Line Crossing People Counting

Camera Imaging Technology

As a key part of the CCTV system which stands for closed-circuit television and is commonly known as video surveillance, network camera imaging usually consists of a lens, imaging sensor (mainly CCD/CMOS), image signal processor, digital signal processor and circuit. Camera Imaging can be applied in various monitoring applications. It is not designed for people counting. But basic on the images, it realizes further people counting to understand space occupancy by an embedded algorithm. Deploying a whole camera system is relatively complicated and not that cost-efficient. It will also cause privacy issues since it captures and stores images and videos.



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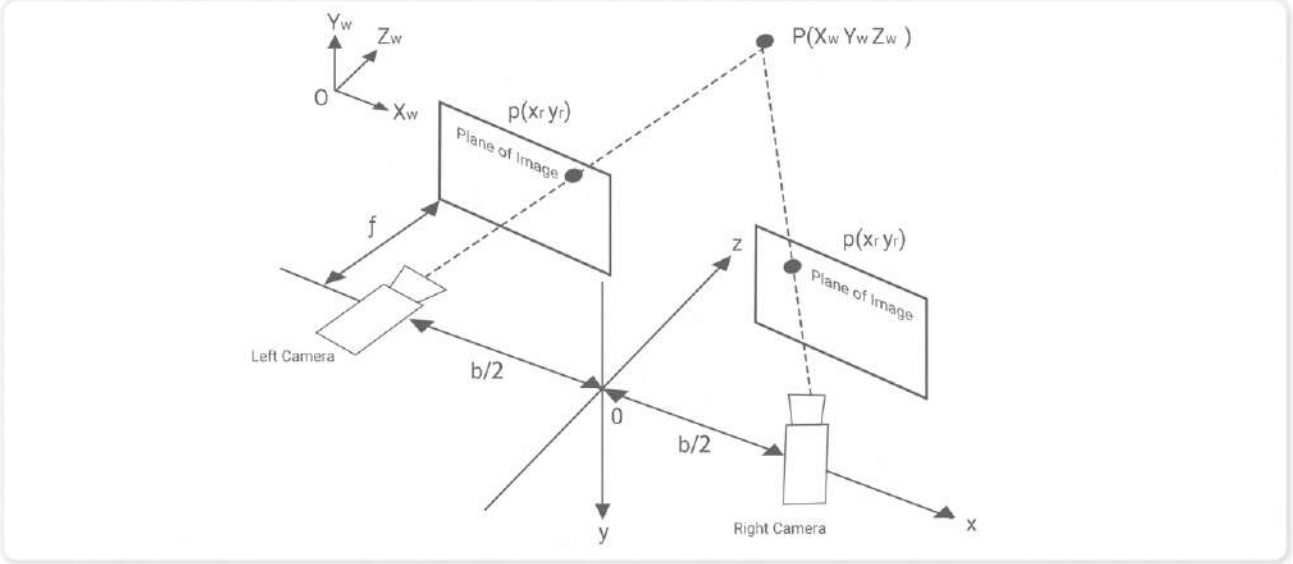
Binocular Vision

3D Binocular Vision is a category of 3D Vision, which is a kind of bionics technique. It imitates two human eyes capable of facing the same direction to perceive a single three-dimensional image of its surroundings. Binocular Vision acquires 3D information by the principle of trigonometry, that is, a triangle is formed among the image planes of the two lenses and the detected object. Knowing the positional relationship between the two lenses and the coordinates of the object in the left and right images, the 3D size of the object in the common field of view of the two lenses and the 3D coordinates of the feature points of the object in space can be obtained. Therefore, the binocular vision system is generally composed of two lenses.

However, in low light conditions or if the object/scene has few textures, it would be hard for the cameras to extract stereo features. The stereo matching method of this technique requires the great processing power of the sensor to guarantee resolution and instantaneous output. Constrained by baseline, namely the distance between the two lenses, stereo cameras work in short range, often within 2 meters.



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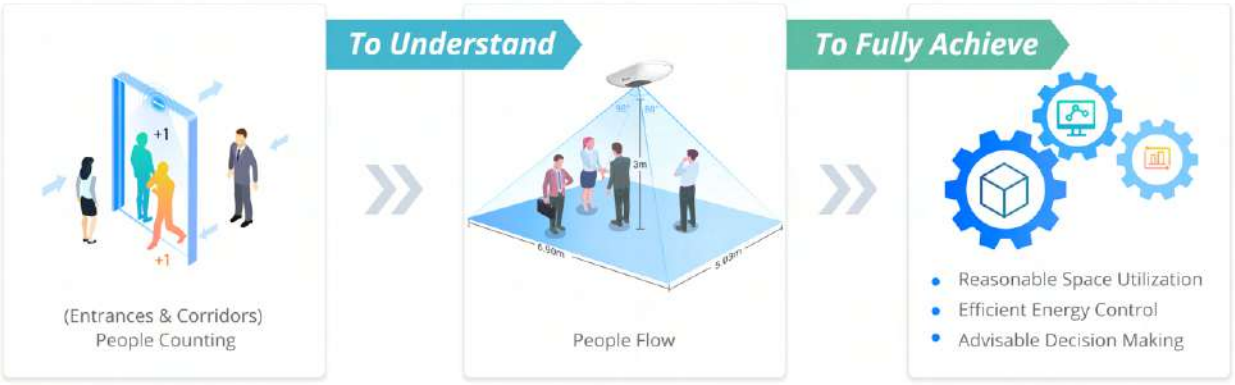
Technology	Accuracy	Privacy	Price	Advantages	Disadvantages
ToF	√√√√	Don't have privacy concerns	$$$$	1. Free from external lighting source 2. Don't have privacy concerns	1. High power consumption 2. Can be influenced by outdoor hard light 3. Limited in installation height
Wi-Fi and Bluetooth Tracking	√√	Has privacy concerns	$$	1. Price superiority 2. Make use of the existing network	1. Low accuracy 2. Easily influenced by obstacles 3. Will miss the targets not using Wi-Fi or Bluetooth devices
Thermal Imaging	√√√	Don't have privacy concerns	$$$	1. Accurate in detecting whether there is people 2. Don't have privacy concerns 3. Won't be influenced by lighting conditions	1. Low resolution, only support side mounting 2. Easily influenced by obstacles 3. Wrong detection if there is objects with similar temperature to humans
Radar	√√√	Don't have privacy concerns	$$$$$	1. Don't have privacy concerns 2. Wide detection range and long detection distance	1. Can't detect static objects well 2. Multipath effect 3. Can't detect close objects well 4. 4D radar algorithm is difficult
Infrared Break Beam	√√	Don't have privacy concerns	$$$	1. Price superiority 2. Accurate in detecting whether there is people	1. Low accuracy 2. Easily influenced by obstacles
Binocular Vision	√√√√	Has privacy concerns	$$$$	1. High Accuracy 2. Target Filtering 3. Has the advantage in mounting height 4. Capture rich information with high resolution	1. Can't perform well under low light conditions 2. High price 3. Complicated algorithm
Binocular Vision Plus ToF	√√√√	Has privacy concerns	$$$$$	1. High Accuracy 2. Target Filtering 3. Has the advantage in mounting height 4. Capture rich information with high resolution	1. Can't perform well under low light conditions 2. High price 3. Complicated algorithm

Milesight People Counting Solution

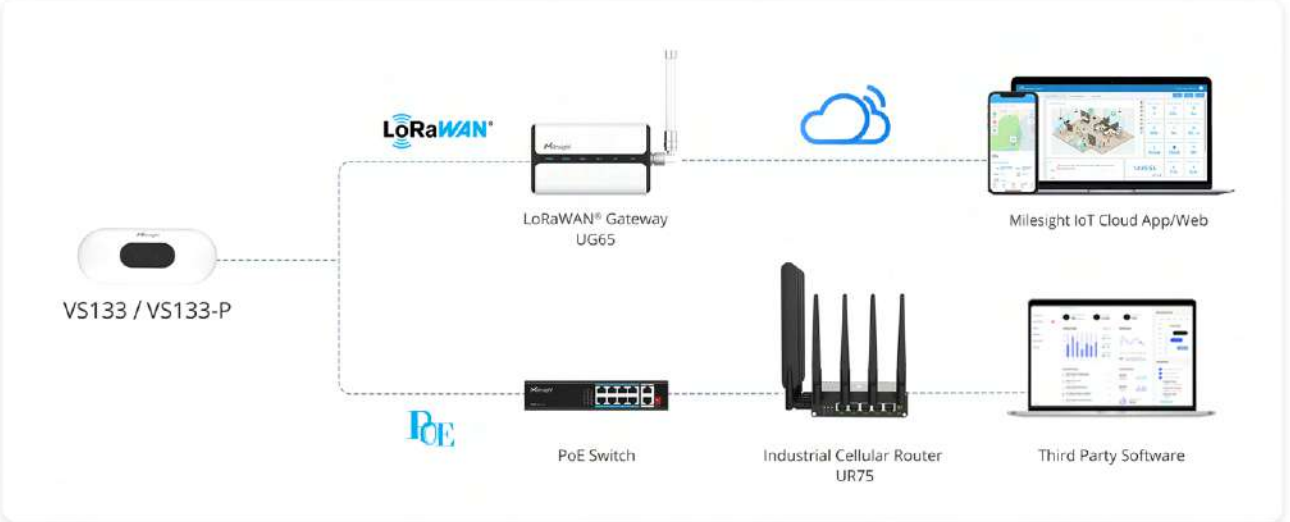
Technology Advantages

AI plus ToF is a technology combination that emerges as a hot spot for comprehensive performance. Unlike binocular vision and camera imaging which get images and videos, it eliminates the fear of privacy concerns by only getting 3D depth information. Furthermore, the outstanding people counting capability which is based on ultra-high accuracy reaching 99.8%, distinguishing it from Wi-Fi, Bluetooth, thermal imaging and infrared break beam. Those technologies lacking enough accuracy may lead to false or missing detection. And considering technology difficulty, radar and binocular vision have disadvantages in cost performance. In general, ToF is a high cost performance technology accurately and anonymously covert numbers into decision-making insights.



Topology

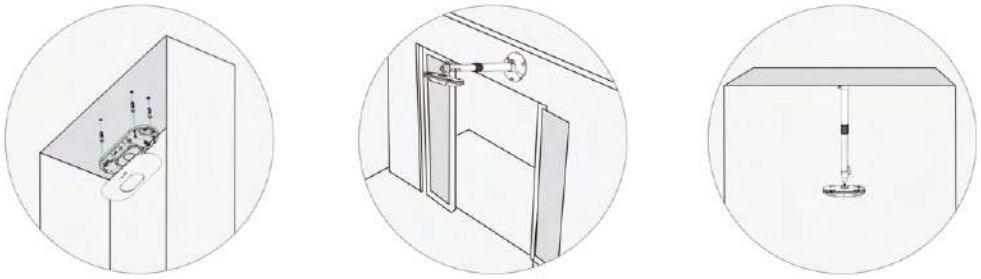
Milesight AI ToF People Counting Sensor counts people in entrances and corridors. The ToF technology guarantee quality performance in even completely dark environments. It allows the sensor to collect data in real-time accurately. Through LoRaWAN® or Ethernet, the information can be flexibly transmitted by Milesight LoRaWAN® gateway or PoE Switch and connected to Milesight IoT Cloud or third-party platforms. Featuring great extensibility, it can well compatible with third-party platforms via open APIs or MQTT/HTTP/HTTPS for wider applications, easily converting numbers into insights for maximum benefits.



Application Scenarios and Benefits

Line crossing people counting is mainly used for businesses like retail stores, shopping malls, supermarkets, commercial buildings and transportation. Also, it provides the possibility for smart linkage of control like HVAC systems and facilities. Where there is concern about traffic there is the Milesight AI People Counting Sensor. The data collected will be an operational database to drive intelligent management and reasonable decision-making. The statistics-based analysis enables operators to convert people counting data into informed decisions. Different people flow of various time buckets efficiently activate business and management values for administrators. And it allows for a better understanding of space utilization and intelligently optimization of energy consumption.

- **Flexible Installation**



- **Application Scenarios**

Based on the onboard AI algorithm and ToF technology, Milesight AI ToF People Counting Sensor VS133 is an advanced sensor for accurate people counting. It is compliant with GDPR. The features of ToF and products ensure 100% anonymous detection at source. Featuring 99.8% ultra-high accuracy and superb performance, it extremely sparkles in applications, forming timely and integrated information for achieving the most profit.

Milesight

BETTER INSIDE, MORE IN SIGHT