

What is ToF technology?

ToF, ToF sensor, ToF optical ranging

Ultrasonic distance measurement and infrared distance measurement are active in the sensing market. As people become familiar with light, optical distance measurement gradually begins to occupy the sensing market, and laser distance measurement is one of the main research directions. The FlightSense™ technology was created using the ToF principle and the Time of Flight (ToF) sensor was introduced.

<https://youtu.be/TpjnooXhOmY>

Understanding Optical Time-of-Flight (ToF) Technology

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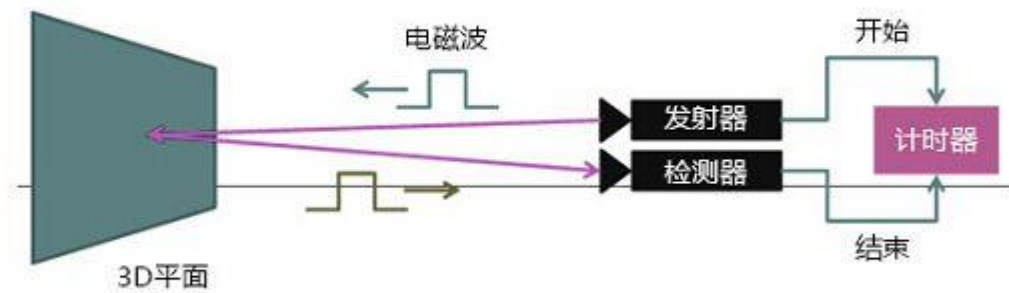
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I ToF technology

ToF is the abbreviation of Time of Flight. The sensor emits modulated near-infrared light, which is reflected after encountering an object. The sensor calculates the time difference or phase difference between light emission and reflection and converts the distance of the photographed scene to produce depth information. ToF technology also combined with traditional camera shooting, which can present the three-dimensional outline of the object in a topographic map with different colors representing different distances. Whether it's autonomous driving, VR, or the endless balance of vehicles on the market, it is inseparable from ToF technology.

1.ToF measurement principle

The emitted infrared light is reflected by the object to be measured and then returns to the sensor. The built-in timer records the back and forth time, and then the distance can be calculated. It sounds like it's no different from the ultrasonic ranging. But it is not the case. Ultrasonic distance measurement requires relatively high requirements for reflective objects. Objects with small areas such as lines and cones cannot be detected. ToF infrared distance measurement can completely overcome this problem. At the same time, ToF distance measurement accuracy is high, measurement distance is long and the response is fast.



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ToF measurement principle

This technology is basically similar to the principle of the 3D laser sensor, except that the 3D laser sensor scans point by point, while the ToF camera obtains the depth information of the entire image at the same time.

2.Advantages of ToF

Compared with stereo cameras or triangulation systems, ToF cameras are small in size and not much different from the size of ordinary cameras. They are very suitable for occasions that require light and small cameras.

ToF camera can quickly calculate depth information in real time, reaching tens to 100fps in-depth information of ToF. The binocular stereo camera needs to use complex correlation algorithms, and the processing speed is slow.

The depth calculation of ToF is not affected by the grayscale and features of the surface of the object, and it can perform three-dimensional detection very accurately. The binocular stereo camera requires the target to have good feature changes, otherwise the depth calculation will be impossible.

The depth calculation accuracy of ToF does not change with the change of distance, and can basically be stable at the cm level, which is very meaningful for some large-scale motion applications.

3.Comparison of 3D depth camera technology solutions

ToF is just one solution in 3D depth camera technology. At present, the mainstream 3D depth camera has three solutions: structured light, ToF, and

binocular imaging.

Structured Light:

After structured light projects specific light information onto the surface of the object, it is collected by the camera. According to the change of the light signal caused by the object, the position and depth of the object are calculated, and then the entire three-dimensional space is restored. (Apple iPhone X uses this solution)

ToF (Time of Flight):

ToF system is a kind of light radar system, which can transmit light pulses from the emitter to the object. The receiver can determine the distance of the measured object by calculating the running time of the light pulse from the transmitter to the object and then back to the receiver in pixel format.

Binocular imaging (Stereo System):

Binocular imaging uses dual cameras to shoot the object, and then calculate the distance of the object through the triangle principle.

	结构光	TOF	双目测距
基础原理	单相机和投影条纹斑点编码	红外光反射时间差	双相机和图像相关
响应时间	慢	快	中
低光环境表现	良好、取决于光源	良好（红外激光）	弱
强光环境表现	弱	中等	良好
深度精确度	中等	低	高
分辨率	中等	低	中高
识别距离	短（mm~5m左右），受光斑图案影响	中等（1~10m），受光源强度限制	依赖于两颗摄像头的距离
软件复杂度	中等	中等	高
材料成本	高	中等	高
功耗	中等	低	低
缺点	容易受光照影响	总体性能好，平面分辨率低	不适合昏暗环境
代表厂商	iPhone X、PrimeSense、英特尔	英飞凌、微软、Toshiba、意法半导体	微信: NWbrCGQJS

Comparison of 3D depth camera technology solutions

Among the three schemes, binocular range finding imaging is easily interfered by environmental factors due to low efficiency, difficult algorithms, poor accuracy, and easy interference from environmental factors; the ToF scheme also has accuracy defects, and the small size of the sensor has a great impact on the resolution.

II Application of ToF technology

ToF sensors can be used in a range of consumer, automotive and industrial applications, including the combination of artificial intelligence and 3D imaging to achieve various intelligent sensing and recognition functions that change the limitations of traditional 2D vision. At present, ToF sensors are considered to be one of the key technologies to realize IoT, and they play a huge role in various fields such as smart home, smart security, smart retail, smart medical, and smart agriculture.

1. Vehicle electronics

In automotive applications, ToF can be used for automatic driving, collision avoidance automatic braking, OOP, and so on.

A camera driver assistance system based on Infineon's 3D image sensor chip launched by Infineon and KSD. Supported by the time-of-flight (ToF) principle, the system can accurately detect the position of the driver's body and head. It can even capture the blinking motion of the driver when he wears glasses or sunglasses to determine whether the driver is sufficiently focused, thus starting the corresponding countermeasures. For example, by vibrating the seat or warning sound. The less the driver's attention is, the more the car will pay attention. In order to respond quickly and accurately, the auxiliary system and the emergency braking system can be automatically activated before a potential emergency occurs.

Infineon 3D image sensor chip

In addition, the technology can also control car entertainment systems or car air conditioners through hand movements or body postures, and even implement new auxiliary and safety functions outside the car, such as door opening aids. Gestigon, Infineon's solution design partner, demonstrated at the conference how Infineon's ToF sensor can realize vehicle object tracking and gesture recognition to achieve "three-dimensional virtual reality".

2.Human-machine interface and games

ToF provides a real-time remote image, so it can be used very simply to record human movements. This makes many consumer electronics products (such as TVs) have a new way of interaction, and the Xbox Kinect second generation uses this technology.

Kinect is equipped with a Depth sensor, which can obtain Depth data (distance information from the sensor). The entire Kinect is actually a big bat. The infrared projector continuously emits infrared structured light, which is equivalent to the sound waves emitted by the bat. The intensity of the infrared structure light to different distances will be different, as sound waves will attenuate. The infrared sensor is equivalent to the ear of a bat and is used to receive feedback messages. Structured lights of different intensities will produce different intensities of induction on the infrared sensor. In this way, Kinect knows the depth information of the object in front of you and the objects are distinguished.

3.Mobile phone auto focus camera

Taking the ToF sensor used in mobile phone auToFocus as an example, the previous auToFocus function usually uses a set of data calculation methods integrated in the mobile phone image signal processor. When the viewfinder captures the most original image, the image data will be used as raw data and sent to the image signal processor. The image signal processor analyzes the original data and checks the density difference between adjacent pixels in the image. Picking out the best image is the photo presented before our eyes. The auToFocus system using the ToF sensor focuses by detecting the distance between the object and the camera, reducing the number of image frames captured by the camera, and capturing images quickly and clearly even in low light. In terms of shooting video, the movement within two meters can carry out accurate ranging and capture images.

In the future, the distance measurement of the ToF sensor will increase the sensing distance, and the receiver needs to be able to detect more photons. In addition to the structure, it also needs optical assistance. It can also capture more photons through the concave-convex lens to achieve greater optical ranging of distance. It will become one of the most basic technologies to realize our future intelligent social living environment.

III FAQ

1.What do you mean by time of flight?

Time of flight (ToF) is the measurement of the time taken by an object, particle or wave (be it acoustic, electromagnetic, etc.) to travel a distance through a medium.

2. Is lidar time of flight?

Laser-based time-of-flight cameras are part of a broader class of scannerless LIDAR, in which the entire scene is captured with each laser pulse, as opposed to point-by-point with a laser beam such as in scanning LIDAR systems.

3. What is the use of time of flight sensor?

A ToF camera sensor can be used to measure distance and volume, as well as for object scanning, indoor navigation, obstacle avoidance, gesture recognition, object tracking, and reactive altimeters. Data from the sensor can also help with 3D imaging and improving augmented reality (AR) experiences.

4. What is time of flight principle?

The Time-of-Flight principle (ToF) is a method for measuring the distance between a sensor and an object, based on the time difference between the emission of a signal and its return to the sensor, after being reflected by an object.

5. What is ToF in Mobile?

Time-of-flight or ToF cameras are becoming a standard feature of smartphones. These ToF cameras measure depth in a scene – and are used to help map the surroundings, and to navigate around obstacles, and much more.