SICK AG WHITE PAPER

LOGISTICS AUTOMATION: MORE PERFORMANCE WITH 3D SNAPSHOT SENSORS

AUTHORS

Dr. Nadja Nagel
Applications Engineer – 3D Compact Systems
SICK AG Waldkirch/Germany

Dr. Fabian Zimmer
Applications Engineer – 3D Compact Systems
SICK AG Waldkirch/Germany

Dr. Anatoly Sherman
Head of Product Management, M&S, Applications Engineering – 3D Compact Systems
SICK AG Waldkirch/Germany

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Sensor Intelligence.

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3D Snapshot Sensors: Intelligent Sensory Organs for Intralogistic Processes

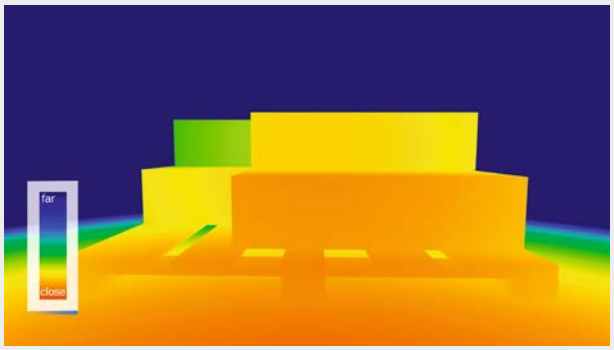
Freight measurement for storage space optimization, position detection for robot guidance, or driver assistance for collision warning – these and other essential solutions for logistics-related applications can be implemented very efficiently using sensors based on 3D snapshot technologies. 3D snapshot comprises 3D time-of-flight cameras as well as stereo and active stereo cameras [1] that are able to deliver valuable and customized data for autonomous work processes and Logistics 4.0 [2] scenarios.

In order to allow a seamless integration, state-of-the-art 3D snapshot sensors offer an integrated intelligent and flexible data processing framework that runs on the sensor itself. Such sensors either directly provide the necessary data or can be easily programmed to fit into edge computing concepts for logistics. Furthermore, they offer the communication interfaces necessary to enable further data processing and utilization – on the premises or in the cloud.

State-of-the-art 3D snapshot sensors calculate the depth and 2D data directly on the device. They also provide uncomplicated configuration and filtering options via the user interface. This enables them to be optimized for the specific application: the filters, for example, reliably remove measurement information that is irrelevant for environment monitoring or object detection. This ensures a high measurement certainty and system availability for specific application scenarios. Particularly important to OEMs and machine vision integrators is the optional provision of the sensor information as raw data. To incorporate this data into custom software solutions, a variety of programming languages such as C++/C# or Python as well as software interfaces and libraries, for example, for the Robot Operating System (ROS), HALCON, or GenICam, are commonly asked for by camera operating entities.

3D snapshot: more than just a snapshot

3D snapshot refers to a fast image acquisition process where the camera or sensor records a complete grayscale or color image of the scene at a specific moment (2D) while at the same time determining the distance between the sensor and the recorded environment as depth values (3D). Thereby, no scanning or relative movement is necessary. The data is acquired in one shot. Furthermore, 3D snapshot sensors are very rugged because of the absence of moving mechanical parts such as deflector mirrors. This results in a high reliability while also minimizing maintenance costs.



3D data

All 3D snapshot cameras provide the measured distance to the camera for each individual pixel (shown here in different colors: red = near, blue = far). In addition, a color or grayscale image of the environment is acquired.

2D data

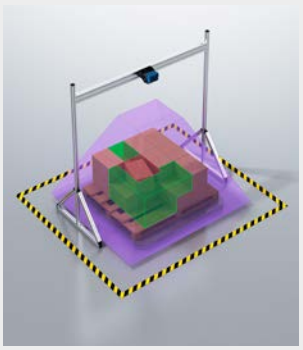
Just like with any 2D image, the color or grayscale data acquired by any 3D snapshot sensor contains valuable image contrast information that further expands the range of applications for sensors based on this technology.

3D Snapshot Technologies for Environmental Perception

Different applications have different requirements. Even within intralogistics there is no one technology that is best for all applications. Therefore, it is a big advantage that 3D snapshot sensors comprise different underlying technologies. The most common 3D snapshot technologies found in industrial automation are 3D time-of-flight, 3D stereo vision (stereo), and 3D structured light stereo vision (active stereo). Each of these technologies offers application-specific advantages. Industrial sensors based on this 3D snapshot technology are designed in such way that their installation and operation allows for easy integration and fast operational readiness. During operation, they are characterized by their application-specific data quality, precision, and repeatability as well as their high level of ruggedness and reliability. A comprehensive portfolio of such industrial 3D snapshot sensors is, for example, offered with the Visionary products from SICK.

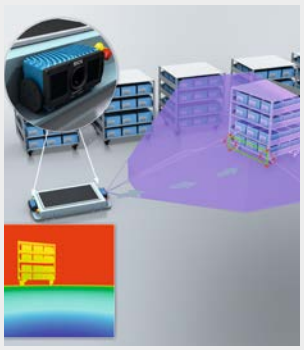
Load Detection, Dimension Measurement, Collision Avoidance, and Robot Guidance with 3D Time-of-Flight

3D time-of-flight (ToF) sensors, such as the Visionary-T Mini from SICK, determine distance and size information of objects within their field of view. Decisive quality criteria are powerful illumination and a sensitive receiver. To cover most of the applications, a typical working distance of up to at least 10 meters is required. The active illumination of 3D ToF sensors allows them to achieve comparably high depth measurement accuracies, even in dark environments and over larger distances (up to 60 meters). Today, sensors based on this technology can be found in numerous intralogistics applications. When installed on automated guided vehicles (AGVs), they ensure reliable 3D collision warning output. Sensors with a high performance can then, for example, reliably detect dark obstacles that might be protruding into the path of the vehicle at different heights – from above or from the side and even under challenging ambient light conditions. By evaluating the data directly on the device, they deliver information such as the status or the fill level of load carriers such as containers, mesh boxes, racks, or pallets. Capturing the contours and dimensions of freight, for example, of loaded pallets, is another example of an intralogistics application that is solved by 3D ToF sensors. Transport systems for airport baggage where bags, suitcases, and packages need to be identified and classified or their volume needs to be measured can also benefit from the quick availability of measurement data from such 3D vision sensors. Acting as the eyes of a robot, these snapshot sensors are also ideal for precise visual guidance. In logistics processes involving the picking of somewhat larger objects such as polybags or sacks from bins, as well as in automated palletizing and depalletizing of containers, the sensors ensure a high gripping reliability even over larger working ranges while offering a very good price-performance ratio.



Level measurement and load optimization

Using the data already evaluated on the device, the sensor delivers information such as the status of the load, or the level of load carriers such as containers, mesh boxes, racks, or pallets.



AGV/AMR navigation support

The 3D measurement data collected by 3D time-of-flight sensors can be used to support AGVs/AMRs for navigation, e.g., to avoid collisions or calculate the position of a dolly and its relevant corner point coordinates or pallet pocket coordinates.

Rugged and Intelligent Driver Assistance and more with 3D Stereo Vision

3D stereo vision technology is predestined to design sensors for applications that demand a wide detection zone, a high level of mechanical durability, as well as flexible integration options. Stereo vision sensors work with two synchronized cameras that have slightly different viewing angles on the scene. Based on the resulting offset between the two 2D images (snapshots) distance values can be calculated by the sensor. This way, stereo vision can provide 2D and 3D images of the surrounding environment. Stereo sensors are therefore very well-suited for advanced driver assistance for collision warning that offers a 2D live view for the driver on top of sophisticated 3D object detection and classification which actively warns the driver of relevant obstacles. Industrial vehicles have large blind spots that pose an imminent danger for collisions, especially when turning, maneuvering, or reversing. By making use of the 2D and 3D data, special AI algorithms that are implemented on the sensors, reliably warn the driver while hiding irrelevant information about the surroundings. Hence, the driver only receives an alert if there is an actual risk of a collision. False alarms that would have a negative impact on the drivers' trust and acceptance in the sensor are avoided. The fact that stereo vision sensors can be designed with a wide field-of-view (up to, e.g., 120° x 75°) is not only beneficial for collision warning, but generally for tasks that require environmental perception of a large volume of the surrounding environment, such as object localization and tracking or volume measurement in harsh outdoor environments. Industrial stereo vision cameras, such as the Visionary-B cameras from SICK offer the flexibility to choose between a plug-and-play solution or raw data streaming to solve various applications, such as the ones mentioned above.

Driver assistance for collision warning

Mounted on a forklift truck, a 3D stereo vision sensor actively warns the driver when there is the risk of a collision while reversing.

3D environmental perception outdoors

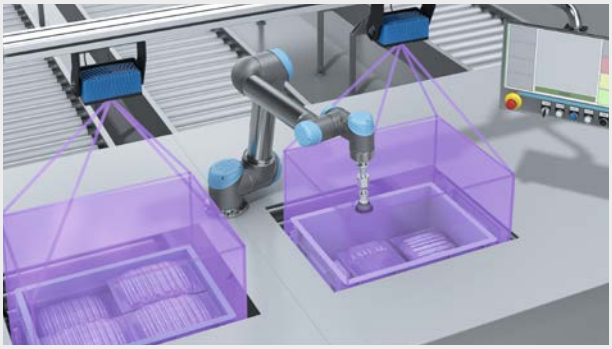
3D stereo vision technology allows to design rugged sensors that work under even harsh outdoor conditions. For example, as collision warning systems on vehicles in ports.

3D Information for Precise Robot Guidance and Accurate Picking Tasks with 3D Structured Light Stereo Vision

Like 3D stereo vision sensors, 3D snapshot sensors based on 3D structured light stereo vision employ the “2-eyes principle.” However, they also use an active illumination with structured light. Such sensors are used when the near-range measurement accuracy is of particular importance for the application. Often, such 3D vision sensors also offer RGB data in addition to the 3D data. Most active stereo cameras used in the industry deliver more than 25 color images per second on top of the 3D images with submillimeter depth resolution. Sophisticated active stereo sensors calculate the depth image already on the device and do not outsource this computationally demanding task to a host PC. Other performance criteria for such kinds of sensors are the robustness against various ambient light conditions that ensure the delivery of high quality depth values in absolute darkness as well as in brightly lit environments. Such high measurement accuracy combined with simultaneous color perception enables, for example, robots to distinguish between different objects in a bin during picking and selectively grip them. Depth values of active stereo vision combined with the contrast values of the color data – i.e., 2D and 3D data fusion – further improves the object detection. This is, for example, the case for applications where bins are densely packed. Depalletizing processes can be designed more efficiently and made quicker due to the precise detection of the position and orientation of the load as well as the measurement of storage heights. This facilitates faster preparation for dispatch and delivery of time-critical goods. Besides the capability to stream the full color and 3D data, modern active stereo sensors offer the possibility to be programmed in such a way that application solutions can be deployed and are being processed on the device itself. Dynamic processes where objects are lying on a conveyor and need to be picked up by a robot with a high gripping reliability demand high image capturing rates and short response times to ensure a high level of efficiency. Amongst others, the Visionary-S cameras from SICK can fulfill these requirements.

Palletizing and depalletizing

Active stereo vision sensors determine the position and dimensions of parcels on the conveyor belt or pallet and transmit their exact position and dimensions to the robot control.



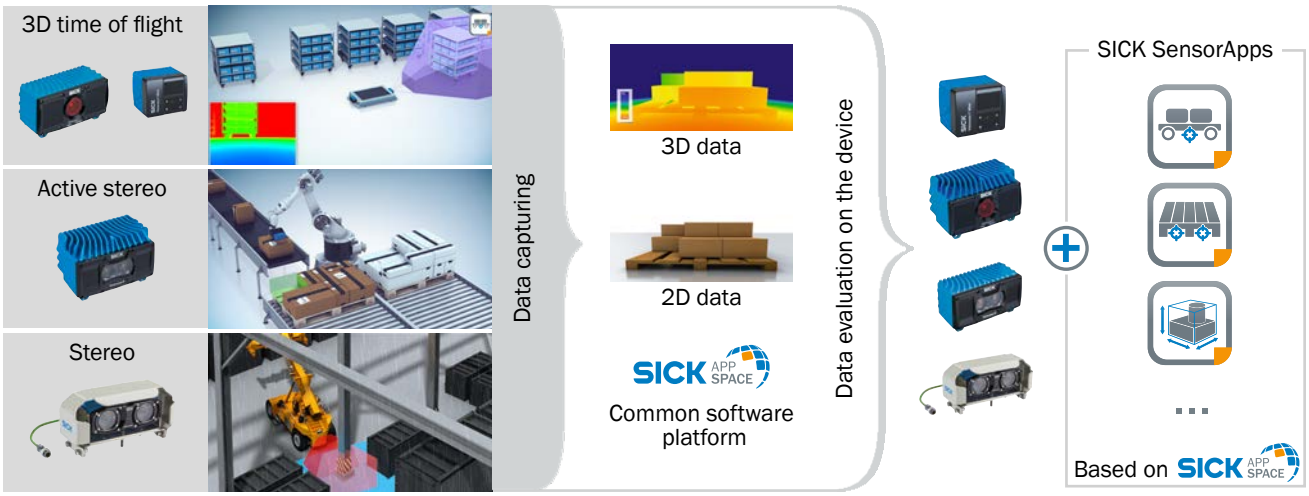
Bin picking: robot guidance and pose estimation

Acting as the “eyes“ of a robot, active stereo vision sensors provide the data to estimate the position and orientation of different goods in trays and boxes. The information is transmitted to the robot controller to pick the individual items and reliably place them.

Software-Defined Sensors Expand the Solution Space

All 3D snapshot technologies mentioned above, 3D ToF for precise data over a big operating range, the outdoor-capable stereo vision, or the near-range, high-precision active stereo sensors with color images, offer 3D data to solve challenging intralogistics applications. 3D snapshot sensors that are programmable are even more versatile and close the gap between a sensor that offers a dedicated application solution and devices that offer raw data streaming only. Advanced industrial 3D snapshot sensors are therefore embedded in an eco-system concept that offers a common programming platform for various sensor technologies and gives 3D machine vision specialists, developers of end customers, or system integrators more freedom and possibilities to develop customized applications and user interfaces.

3D snapshot technologies are evolving very fast as are the 3D vision sensors based on this technology. The market for 3D environmental perception sensors is continuously expanding, for example, with sensors that have an even higher depth resolution, with further programmable variants, and with specific sensor software (SensorApps) running on the devices. In addition, artificial intelligence becomes more and more important in processing and evaluating 3D data. At the same time, we can expect new, more compact designs that satisfy the requirements for machine miniaturization or when installation space on vehicles is scarce. Smaller designs also create more options to integrate 3D vision sensors on collaborative robots.
The market of 3D snapshot sensors is constantly growing but only a few manufacturers offer a complete 3D snapshot product portfolio that allows customers to choose the best solution for the specific application.



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