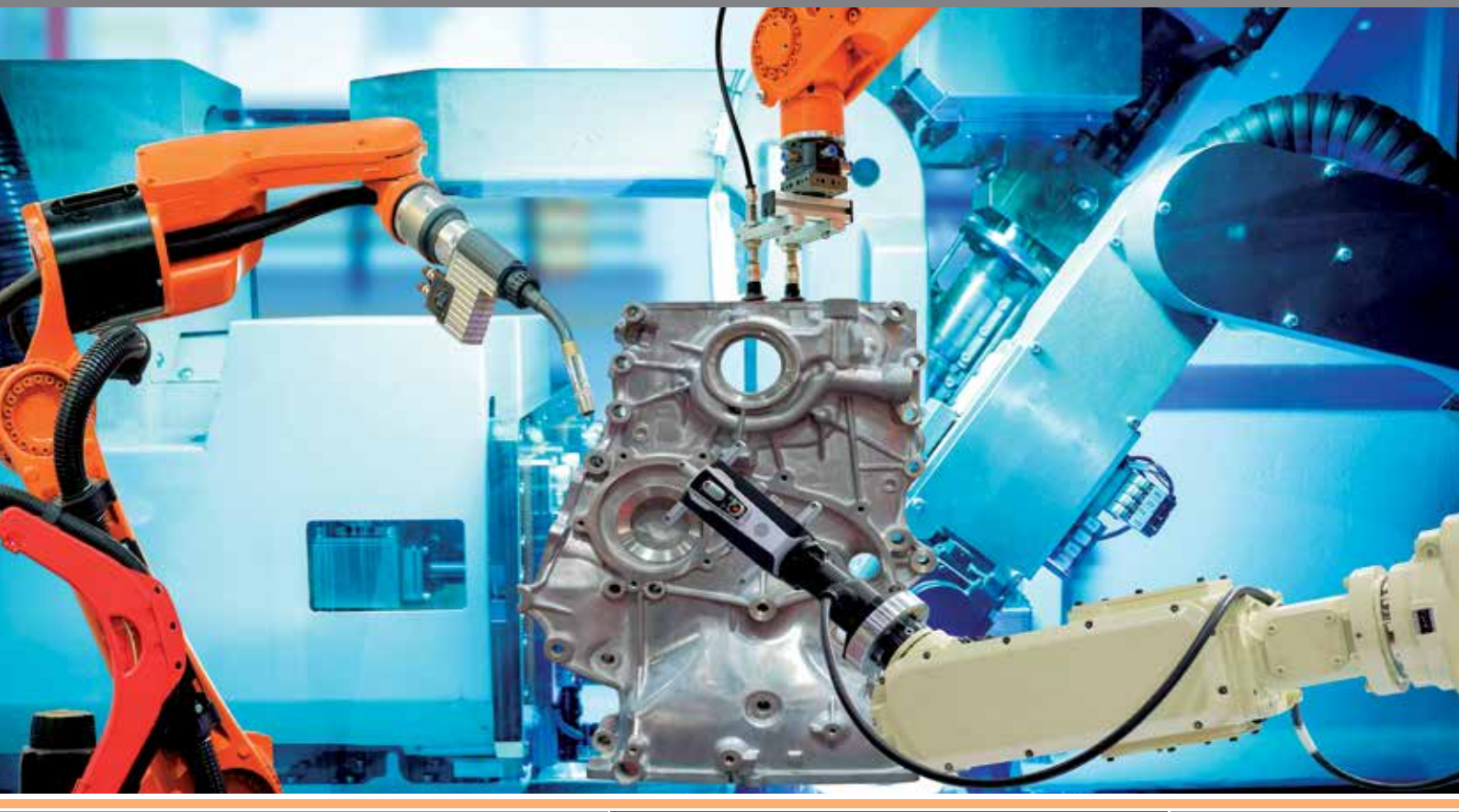
3D INTELLIGENT SENSORS:

ADDING DIMENSION TO YOUR MACHINES



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In an evolving world where efficiency and speed are at the forefront of industrial production, factories are looking to smarter, flexible technology to improve their outputs. Intelligent sensors with 3D technology enable machines to perceive their environment with human-like vision, giving them the ability to work faster and more effectively – even in unstructured environments. The ifm range of 3D imaging sensor technology not only provides solutions for current applications in the production and logistics sectors, but flexibility for customisable, future applications. The possibilities with this innovative technology – particularly in light of the next industrial revolution – are countless.

This white paper provides an overview of the current technology, providing a comparison between intelligent 3D sensor technology and conventional 2D sensor technology and a discussion of the user-friendly, intuitive apps in the ifm 03D vision sensor range. Additionally, this paper reflects on the potential industrial applications of the ifm03D range, including the 03X100 3D product – one of the world's smallest 3D imagers based on the time-of-flight principle.

Overview of the technology

The third dimension offers a plethora of new opportunities in image processing applications. While 2D machine vision is firmly embedded in many industrial applications, the technology is limited and not suitable for the future. In an industrial context, 2D image processing is still the dominant technology for positioning, detection, measuring and reading. 2D vision cameras are suitable in applications where there are obvious contrasts or if the structure or colour of objects can provide a decisive result. With 3D imaging, the complete dimensional data of an object can be captured. These machine vision scanners work by outputting a 'point cloud' – a digitised model that includes both the location and shape of objects.

The **PMD sensor** illuminates the scene with an internal infrared light source and **calculates the distance** by means of the **light reflected** from the surface.

What are the key differences between 2D and 3D?

• Shape measurement
The 2D sensor technology is limited in that 2D sensors do not support measurements related to 3D shape. This means they cannot measure critical features such as object flatness, surface angles or part volumes. This is a disadvantage in production and assembly lines where every aspect of a package or target must be inspected. Whereas 3D sensor technology produces 3D shape information and can provide a more thorough quality inspection.

•Depth and distance
2D vision sensors cannot detect depth and are therefore reliant on the distance that the camera is positioned from the target. The camera sensors must be positioned very precisely and use a scale-invariant feature to counteract the effects of motion. 3D sensor technology can measure depth and provide better detail of a moving object.

• Contrast measuring
2D vision sensors measure an object's contrast – or edge data – to check certain characteristics of the object. The technology relies on lighting and colour or greyscale variation to detect features. This is a problem when inspecting objects with low contrast or where the background is the same colour. Unlike 2D vision, contrast for 3D technology is invariant – the shape is measured regardless of colour and it can work in any type of lighting. Applications include: scanning random parts, scanning packaging with changing images, scanning a range of product colours and isolating a scan of an object from a busy background.

• Robotic inspection applications
2D technology cannot provide the necessary depth or spatial information for vision-guided robotics used for automated quality control. Industrial robots work in a 3D world and a 3D camera sensor gives a robot vision. The robot can then sense variations in the physical environment and adapt as required. This increases the robot's flexibility, utility and speed in applications such as pick-and-place.

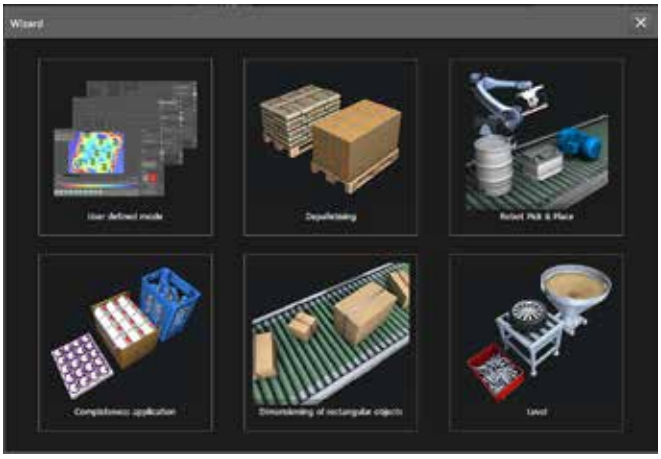
Time-of-flight PMD technology

The ifm 03D 3D camera detects scenes and objects at a glance in three dimensions. In comparison to laser scanners it does not require moving components and is robust and wear-free. It can also work in almost any lighting conditions. The most important element of the ifm 3D sensor system is a patented photonic mixer device (PMD) chip that's function is based on the time-of-flight (ToF) principle. The PMD sensor illuminates the scene with an internal infrared light source and calculates the distance by means of the light reflected from the surface. This ToF technology can be compared with a laser scanner, but instead of one receiving element, there are 23,000 receiving elements that are arranged on the PMD 3D chip as a matrix. This means that not only one point of an object but a complete scene is measured in the visual capture.

The ifm 03D applications

The implementation of the first digital PMD chip came as a result of the partnership between ifm and pmd technologies back in 2005. Since then, ifm has developed a new generation of 3D sensor products that use this vision technology to increase the effectiveness of industrial automation. Applications can be found in areas such as packaging, storage and materials handling, transport logistics, collision avoidance and monitoring of space and persons.

Importantly, ifm has developed a number of user-friendly, intuitive apps to provide customers with a finished 3D sensor product. These sensor products can be used for completeness checks, volume determination or sorting tasks. Their programmed



apps have been designed so that they are easy to install, configure and integrate into existing industrial contexts.

Completeness monitoring

The completeness monitoring programmed app checks that all products are accounted for and in their correct position within a handling unit. This eliminates the potential for shipments to include incomplete units or units with damaged goods. Unlike conventional sensors that rely on clearly defined features such as the type, size, colour or texture of a unit, the ifm 3D sensor looks at a unit from above and compares it with models taught in by the user. It detects for underfill or overfill and then signals any deviation from these models via a switching output.

Volume determination

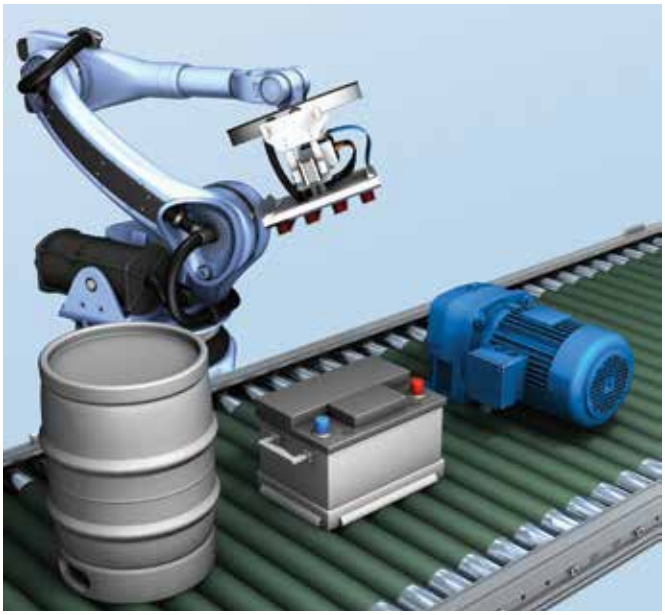
Volume determination ensures the best possible use of a storage space. The ifm 03D sensor and programmed app achieves this determination through the accurate dimensioning of goods as they are fed into a space via conveyor belt. If package parameters are outside the defined areas, the sensor will signal this via threshold values. This application is suitable for any type of storage space, post room, logistics or distribution centre. It is also possible to detect undersized or damaged packages and can be used for logistics companies to charge freight by volume instead of weight. This technology is ideal for automated storage space planning using a Warehouse Management System (WMS) or Enterprise Resource Planning (ERP) system as it provides the size, orientation and position of the objects.

Continuous level measurement

Single point level measurement of bulk materials can be difficult due to the peaks and valleys associated with these materials. The photoelectric 3D level measurement and point level detection capabilities of the ifm 03D sensor and programmed app ensures the reliable and continuous measurement of uneven surfaces with levels up to 10 metres. This is especially useful for determining the levels of solid, opaque solids and bulk materials in tanks, silos or hoppers. The sensor can determine minimum, maximum or mean values. Its measuring segment can also be adapted to suit the shape of the respective tank.

Flexible automation of robot grippers

Automated gripper systems increase the productivity of many applications as they carry out mundane manufacturing steps faster and with more accuracy than humans. Also, moving heavy objects is not good for worker health. When robots take over these tasks it increases the machine uptime and also releases employees for tasks for which they are better suited. The ifm 03D sensor provides a robot gripper with 'eyes'. It detects the position of all kinds of objects (especially those common in a warehouse facility such as boxes, cardboard packages, buckets, kegs, cans, bags, wheels or luggage) and transmits this information to the robot control that operates the gripper. This sensor product is suitable for hydraulic, pneumatic and electrical grippers.



Depalletisation of uniform packages

The automatic depalletisation of packages can significantly improve a logistics process. But localising individual boxes for robotic depalletising can be a slow process that limits the overall throughput. The ifm O3D sensor and programmed depalletising app determines the next box for a robot to pick up while it is dropping the previous case, eliminating the need for pausing between pick ups. Position indication allows for the full automated depalletising of complete layers or individual packages.

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Customisable solutions

The ifm 3D sensor technology is not limited to the above applications – these are market ready solutions where ifm has developed the software and programmed apps as a ready-to-use solution. ToF systems based on the PMD-principle give the possibility of fast 3D measurement with customisable solutions depending on the application.

Models based on combinations of distance, volume or level can be programmed in the user-defined mode to create a customised solution. For more complicated applications the entire point cloud can be sent to a PC or controller via the ifm software development kit. Vision programming software such ROS, PCL, OpenCV and Halcon Libraries is also supported.

The future prospects of this technology are exciting and endless. The latest product available through ifm is the 03X100 3D camera utilising the world's smallest ToF imager. Currently, ifm have sponsored a number of university or research institutes in Australia under their 'Project IRIS' initiative, which encourages students to develop new solutions in VR (virtual reality) and AR (augmented reality) for the working and business world. It will be interesting to see what industrial solutions the young developers come up with using the 03X100 3D product.

The factory of the future

Modern factories rely on digitised computing systems to achieve their production and quality targets. Sensors are an integral part of those systems, providing necessary information on objects along the production line – especially in how items are packaged, transported and stored. While 2D sensors are firmly entrenched in current industrial settings, adding an extra dimension will translate to significant productivity gains and savings. 3D technology is also the way of the future. The cornerstone of the next industrial revolution is automation, and industrial robotics cannot operate to their intended capacity without 3D technology. Simply put, embracing intelligent 3D technology is an investment into the future, while 2D imaging technology is limited to the present. The ifm 03D Smart Sensors range provides affordable, robust solutions to common industrial applications. The modular design of the technology also means it is flexible and customisable for a wide variety of current and future applications.

For more information visit: www.ifm.com/au/en