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INSPECT

World of 3D

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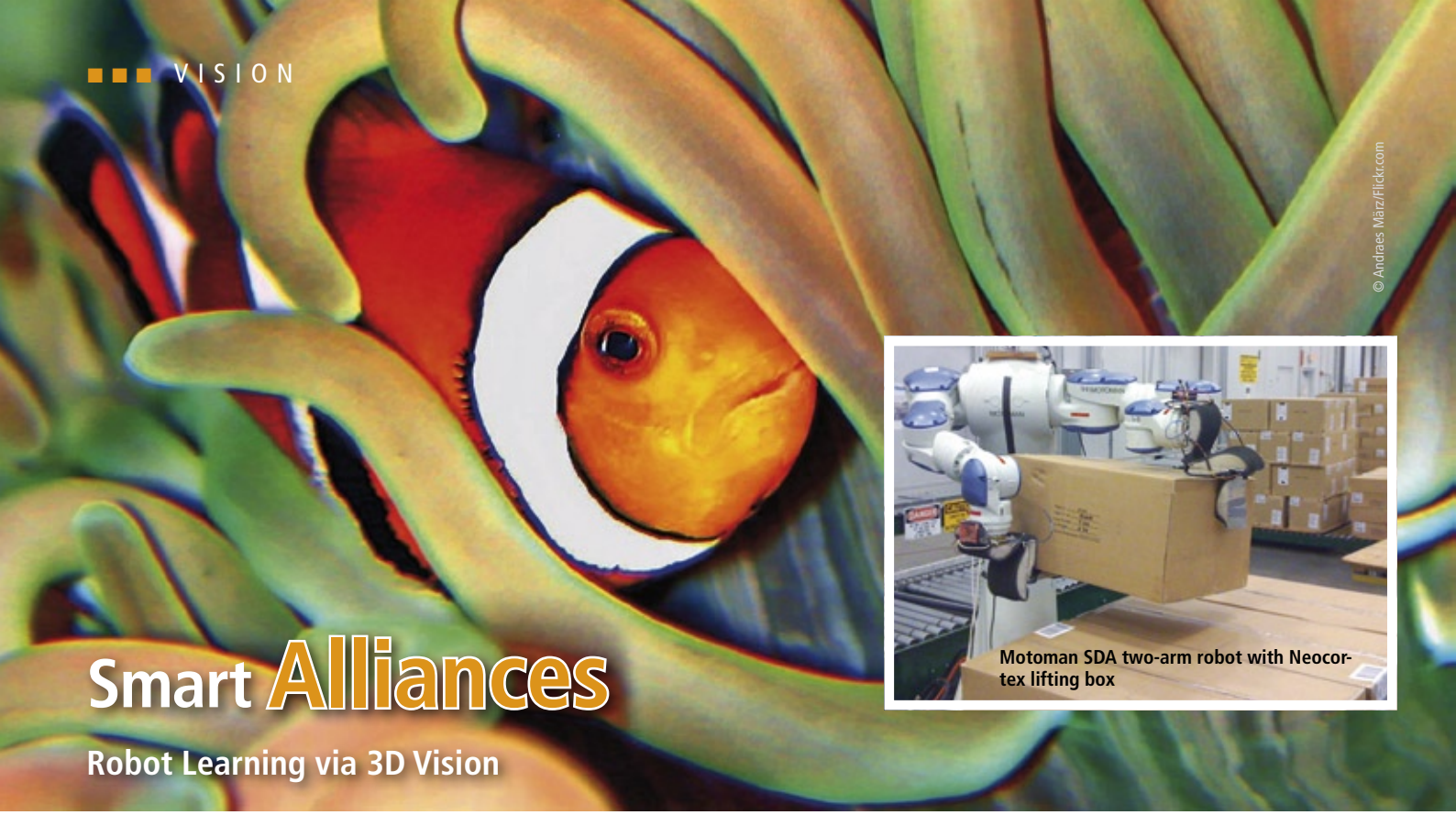

Motoman SDA two-arm robot with Neocortex lifting box

Smart Alliances

Robot Learning via 3D Vision

Traditionally, machine vision or Automated Optical Inspection (AOI) systems have helped produce quality mass manufactured products. These systems provide visual feedback and analysis to very structured processes through filtering, pattern matching, histograms, edge detection, matching shapes, patterns and colors, and taking measurements. Through the use of highly accurate equipment, structured lighting, custom mounting, and extensive programming, a 2D/2.5D/3D vision system is able to play a key role in quality control by recognizing a good product and rejecting a bad one.

New Role for 3D Vision

3D vision systems are playing an essential new role in the field of robotics and are enabling the automation of tasks that have been impossible to automate previously.

Universal Robotics created novel software called Spatial Vision that turns any pair of webcams into a cost-effective and easy to calibrate and install 3D vision system. Spatial Vision was created during the development of Neocortex, a sensory-motor based form of artificial intelligence that enables robots to learn from their experiences and perform tasks that are unsafe or difficult for humans. Through more than 50 channels of sensor data, Neocortex allows a robot to observe its environment and change its actions as necessary in real time to complete a given task.

A Neocortex-enabled robot's sensory data is not just time stamped, but also stamped with 3D vision data. Vision capabilities for this robot include traditional requirements – filtering, pattern matching, histograms, edge detection, object recognition, and measurement taking – as well as real-time 3D positional information blended with multiple modes of sensor data. This enables the robot to react to unexpected changes in the environment, the task, or the object of interest.

While Neocortex has applications in many fields, from underwater mining to bomb diffusing, it has been initially rolled out in the materials handling market, being used as an automated mixed-size box handler. Universal Robotics partnered with Yaskawa/Motoman Robotics to provide a hardware/machine intelligence work cell solution that features

Table 1

Horizontal Resolution (mm) at Camera Distance of 2.0M (6.1 ft)						
Camera Resolution:	MPx	HORIZ Px	VERT Px	Camera Optics -100%	SW at Best Calibration - 80%	SW at Normal Calibration - 60%
CIF	0.1	352	288	7.0	8.7	11.6
VGA	0.3	640	480	3.8	4.8	6.4
HD 16:9	0.7	960	720	2.6	3.2	4.3
SXGA	1.3	1280	1024	1.9	2.4	3.2
UXGA	1.9	1600	1200	1.5	1.9	2.6
HD 1080	2.1	1920	1080	1.3	1.6	2.1
4 MPx	3.9	2288	1712	1.1	1.3	1.8
5 MPx	4.9	2560	1920	1.0	1.2	1.6
8 MPx	8.0	3264	2448	0.8	0.9	1.3
Assumes Horizontal AOV =63 deg; Vertical AOV = 49.5 deg				Horizontal Accuracy (Pixel Size in mm)		

Neocortex software, Motoman's SDA-series robots, custom box moving end effectors and a suite of sensors, including Spatial Vision.

3D Accuracy Required for Two-Arm Robots

In contrast to AOI often being sub-pixel, Spatial Vision's 3D accuracy is based on the pixel resolution of the camera, which allows the selection of the low cost equipment to do the job.

What's required for a two-arm robot to move boxes? In a work cell for a two-arm robot that is about 9 ft in diameter, a pair of cameras would be installed roughly 4–6 inches apart 4 ft above the work area, making the maximum distance from the cameras to the furthest point in the work cell about 6 ft (2 m).

In the chart below, the first row in bold at camera resolution of HD 16:9 with the Logitech 9000 webcams, is what Universal Robotics currently uses for box moving at a depalletization work cell, resulting in 3D resolution of 3–4 mm. With the new Logitech C910 webcam, the second bold row marked HD1080 shows the resolution doubles in accuracy to 1.5–2 mm.

The first colored column shows the horizontal pixel size of the camera optics, or its potential error. The second column shows what Universal Robotics has found is the best possible software resolution based on the best calibration practices. If a user doesn't follow Spatial Vision's calibration wizard and guidance, normal calibration practices typically result in only 60% of the optical resolution.

Learning in an Unstructured 3D Environment

For AOI, very precise visual capabilities are required in order to detect components as small as 50 µm. AOI is also appropriate for assemblies or products that are geometrically precise, have visual characteristics that can easily be measured within specifications, and always vary in ways that can be pre-programmed.

But what if the objects of interest vary with no particular pattern? In the example above, shipped cardboard boxes vary with no particular pattern – many times they arrive dented, damaged, bulging, or worn – all for one identical SKU (Stock Keeping Unit). This is why box moving has not been automated previously. Secondarily, automating a task for the two-arm robot requires the combination of multiple sensor modalities. This shifts the complexity and intelligence from the specialized hardware and sensors to the parallel processing of many generic sensors such as vision, touch, force, infrared, etc., lowering the cost of automation.

Accurate industrial 3D vision systems typically start at US$ 10,000 and can easily exceed US$ 50,000. However, you can buy a USB 2.0 HD (1,920 x 1,080) video webcam that records 1,080 p

Table 2:

Task	Task Time	Sensor Type	3D Spatial Resolution
Identification of boxes, pallet orientation	5%	Pair of webcams	< 4-5 mm
Box moving strategy	10%	NA	NA
Identification of box edges	5%	IR & end effector camera	< 1mm
Path planning	30%	NA	NA
Grip box	20%	Touch flex sensor, force	~ 0 mm
Move box to conveyor	30%	Pair of webcams	< 4-5 mm
Depalletization Task:	100%		

at 15 fps and 720 p at 30 fps for under US$ 100 (see Logitech HD Pro Webcam C910). With USB 3.0 becoming mainstream and offering 10 times the throughput (speeds up to 5 Gbps compared to USB 2.0's 480 Mbps), you will be able to get even more data to the PC through inexpensive USB cameras. With massive parallel processing becoming prevalent (see Nvidia's CUDA parallel computing architecture), the PC's ability to deal with higher computational needs in real-time at a low cost is becoming a reality. The recently-released Spatial Vision Robotics enables fast 3D calibration with a pair of webcams, the calibration of a robot work cell and the correlation of the two with no programming at a fraction of the typical cost.

How Well Does It Work?

Prior to running, a Neocortex-enabled robot records the dozen or so possible ways to pick up any box and then uses these methodologies for any box it encounters up to its payload maximum of about 75 lbs. By providing just the right sensor where needed along the task, the robot is able to take advantage of the visual resolution as needed while keeping the complexity to a minimum. Once the robot is conducting the task, the accuracy and time spent is summarized in the table.

This depalletization solution using Neocortex, Spatial Vision Robotics, and a Motoman SDA robot just exited Alpha stage testing at a customer site moving 3–4 boxes per minute, and is speeding up to 6–8 boxes per minute prior to Beta testing at a major US commercial distribution center, delivering a return on investment of 18–24 months.

A Whole New Field Is Opening

3D vision is on the cusp of a whole new field as it moves from part placement on the assembly line to broad applications in unstructured environments like visual analytics, people tracking, security, new applications for automated robotics, filming, and other areas. Precise 3D positioning embedded in smart cameras and used with automated systems in conjunction with other types of sensors can provide a rich understanding as an environment changes in real-time and the object of interest is in motion.

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GigE Vision Capability for Sony FCB E Cameras

GigE Vision and GeniCam standards committee member, Stemmer Imaging, is delighted to be able to announce the versatile performance of the new Sony FCB E Series of color block cameras with GigE Vision and GeniCam functionality. The new CVC GE family includes a camera equipped with an FGI GigE Vision-compliant interface board produced by Stemmer Imaging and the CVB CameraSuite software development kit. Sony FCB E Series color block cameras offer outstanding performance, including true progressive scan from an HAD CCD image sensor. The camera range features zoom lenses from an industry-leading 36x down to 28x or 18x, combined with 12x digital zoom to bring enhanced versatility.

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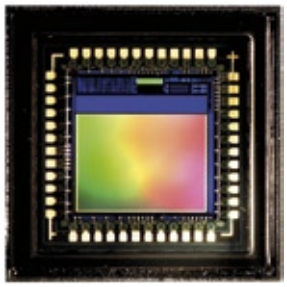
High Speed Solution for Digital Still Cameras



Aptina announced the newest addition to the company's growing portfolio of high-performance image sensors. The 14 megapixel (MP) MT9F002 image sensor integrates the company's latest Aptina A-Pix pixel technology, resulting in an increase of nearly 25% in low-light sensitivity (CCD-equivalent), and providing greatly enhanced, high-quality still image capture over the company's previous 14 MP image sensor. The high-speed MT9F002 sensor combines an enhanced 1.4-micron pixel with advanced features, such as electronic image stabilization (EIS), and digital re-sampling. The new sensor also has full HD (1,080 p/60 fps) video capability, and flexible, high-speed interface options, including four-lane HiSPi (high-speed serial pixel interface) and parallel or four-lane MIPI.

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Free Programmable Smart Camera

Imago Technologies introduces the new VisionCam XS. The camera uses sensors from WVGA up to SXGA resolution or a 2k line sensor together with a Da Vinci processor from Texas Instruments. All the functions of the camera are covered in a C library and an example program. The developer can start directly to program his application. The VisionCam XS addresses the large market of special applications with the added value of the customer program inside. And if the camera does not fit into the application Imago can offer the "big brother" named VisionCam PS: LinLog high dynamic sensors with high resolution, optional 3D functionality and more processor power are able to offer high end application in form of a camera.

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