Advanced Vision System Makes Automated Bin-Picking a Cost-Effective Option

In bin-picking applications, items must be sorted and removed from a bin or tote full of similar or varying items and placed into individual containers for packaging fulfillment or additional manufacturing processes. The job is boring, repetitive, and fast-paced but requires high accuracy and consistency—characteristics that make it an ideal candidate for automation. But while human workers can look at a jumbled bin full of parts and immediately identify the best way to pick up items based on their shape and position, easily avoiding the edge of the bin as they reach inside, the complexities of automating these actions have been prohibitive until recently.

While bin-picking applications always require the system to work with (at minimum) a 3D camera, vision software, and robot arm with appropriate gripper, the real challenge has always been the software. Yes the camera, mounted overhead, scans the bin full of items, but it's the vision software that analyzes the image, defines an appropriate item to be picked up based on position, shape, and ease of access, and communicates that information to the robot arm so it can pick up the piece. And, to date, it's been the vision software that has lacked the sophistication and accuracy to really speed automation in a factory setting. (See Figure 1.)

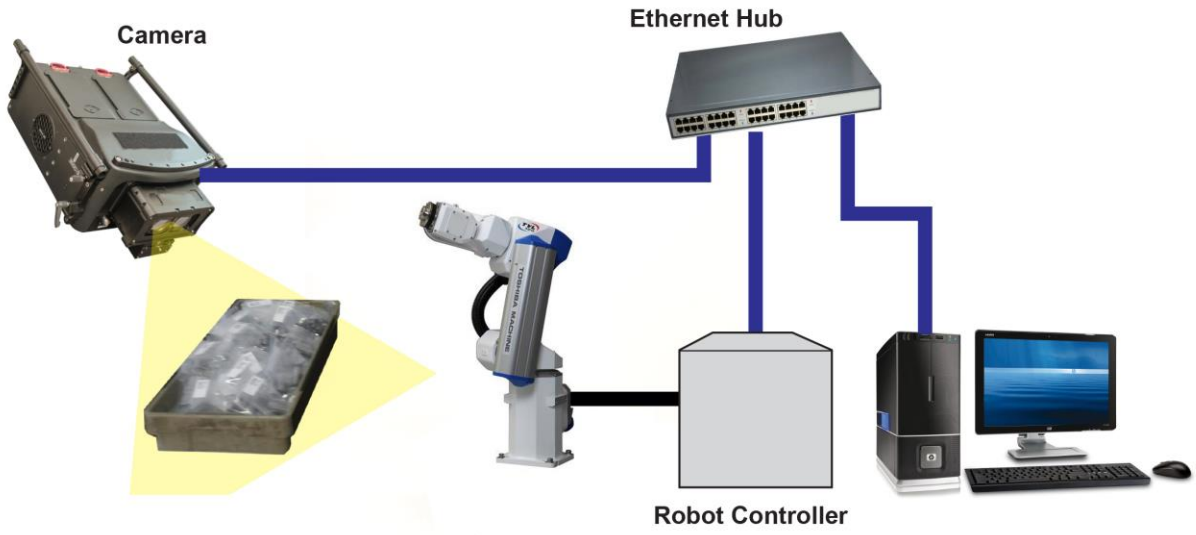

Figure 1. Bin-picking system configuration.

Even with new robot and camera technologies, visions system challenges persist

Challenges to these systems exist at every step. The robot arm must provide full 6-axis movement in order to use varying approach vectors to reach into the bin without hitting the box sides and then pick up items that can be lying on top of each other in a wide range of positions and orientations. The camera must be able to scan, process, and communicate data quick enough to coordinate the robot's actions. And the images captured must be clear enough to show more than just outlines of the items in

the bin. For the robot gripper to effectively approach a targeted item, the position and orientation of items that may be jumbled or overlapping must also be identified.

While advances in 6-axis robot arms and high-speed 3D camera systems have addressed many of these issues, vision system software has continued to be a stumbling block. Typical vision software is expensive and complicated, requiring professional CAD programming to "teach" the robot to recognize models (the computer-defined shapes of the items to be picked). Even after initial programming, it can be difficult for the system to recognize multiple models in a single bin or to recognize the models' positions in the bin in order to identify the ideal approach vector and picking point for the robot. And, of course, if the application changes so that different items need to be picked, the time and expense of professionally reprogramming the system must be repeated. A new approach implemented by Toshiba Machine combines the latest vision system technologies and software to overcome these stumbling blocks, making automated bin-picking a reality even for smaller volume and highly variable applications.

New vision system technology eliminates stumbling blocks with easy programming

The system incorporates two integrated, high-speed stereo cameras that are capable of 30 frames per second for continuous, real-time 3D images. Image capture and processing and parallax operations (to identify items' positions) are performed inside the camera. The camera offers accuracy of ±.07mm at a height of 700mm, with a measurement field of 350mm X 280mm and depth of field of 600mm to 800mm. In order to enhance the camera's accuracy even further, a projector shines a random light pattern into the bin, which highlights the surfaces of the items inside and gives the camera additional position and orientation data for more accurate identification. (See Figure 2.)

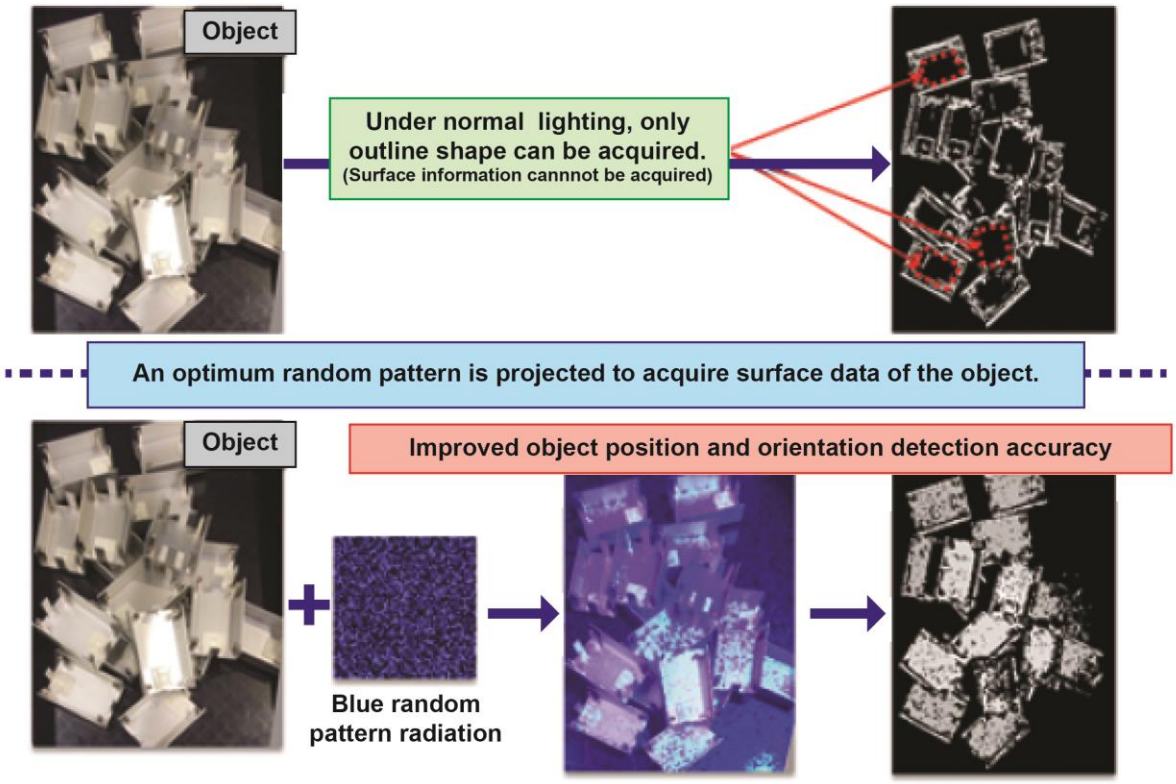

Figure 2. Random pattern projection improves accuracy.

The vision software offers easy model registration without requiring complex CAD data. The software registers a model by capturing an image of the item with the camera and simply using a mouse to enclose the image. After capturing sample work pieces multiple times in different positions and orientations, the vision system automatically generates composite model data. If there are multiple parts, the recognition rate of a single item can be improved using the mouse to mask unnecessary parts. (See Figure 3.)

Once the model has been registered, calibration of the camera and the robot base-coordinate system is just as simple. The camera captures images of the model multiple times in different positions and orientations while it is held by the robot, and the vision software calculates the part's position and altitude. Multiple picking points can be identified, and an optimum picking point selected. (See Figure 3.) During this process, multiple models can be registered and parameters easily adjusted. The system also allows the user to easily measure the bin position, opening area, and height using the mouse. That allows the software to guide the robot arm for the most effective approach vector so that the arm doesn't collide with the bin and the tip picks up parts that don't interfere with the box. The software walks even untrained users through each step of repositioning the robot arm and measuring the bin, so no special training or programming expertise is required. (See Figure 4.)

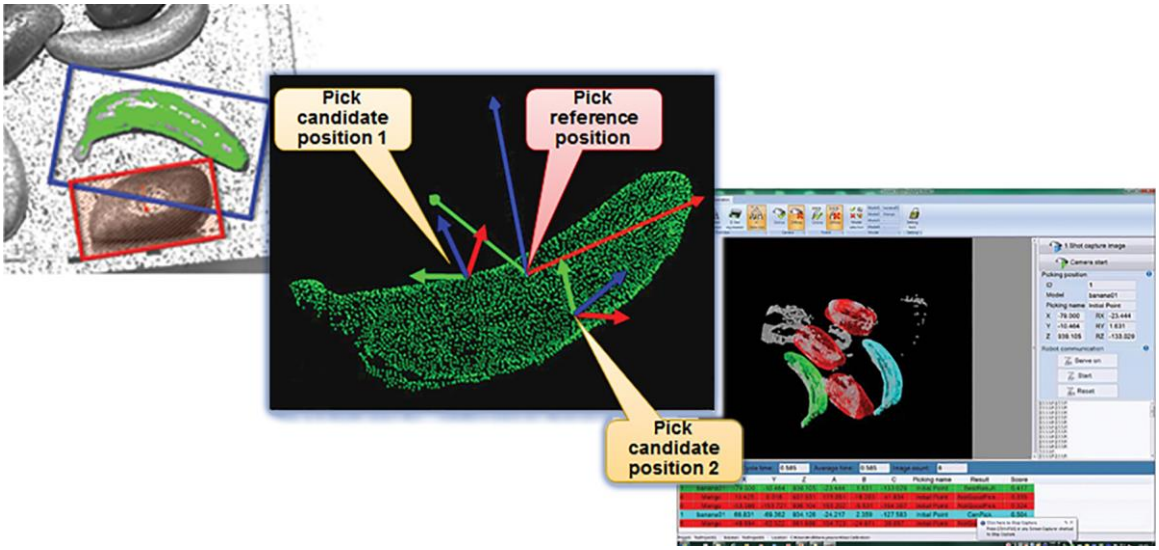

Figure 3. Multiple models can be easily registered using a mouse, with multiple pick points identified. Parameters can be easily adjusted.

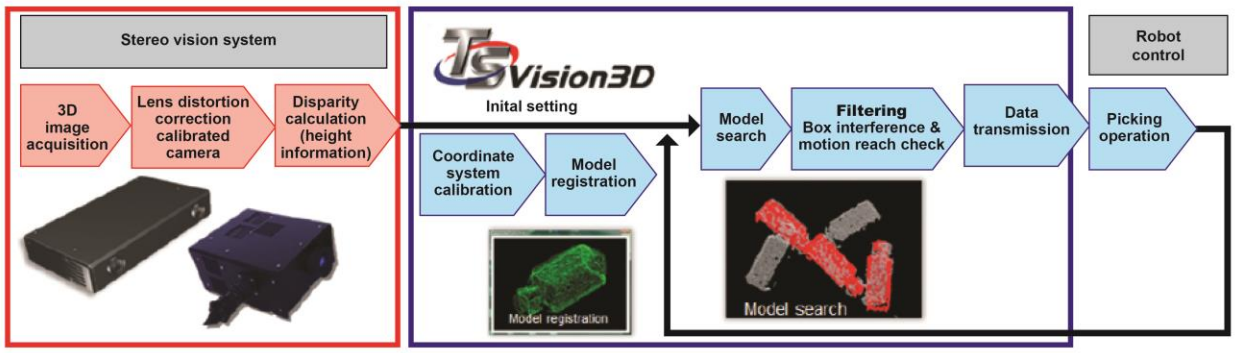

Figure 4. The TS Vision3D system incorporates multiple steps for high-accuracy, high-output automation.

The system can incorporate multiple robotic options, depending on application needs, and easily interfaces with other systems on the production floor. For instance, a Cartesian robot could fill and transport totes, while SCARA or 6-axis robot picks items for packaging or binning.

New vision system and robotic automation result in ideal bin-picking solution

2D vision sensors have long been the standard for robotic automation systems. But because these sensors can only recognize two-dimensional position and posture, it was often necessary to design and implement a separate pre-process mechanism to remove objects' overlap and align the parts in order to correctly perform position detection and picking. These additional processes worked against the desired process automation and labor reduction. While expectations have been high for systems that take advantage of 3D vision sensors and robots that can pick objects from bulk, such systems traditionally involved multiple technical hurdles such as installation methods and programming know-how, as well as prohibitive implementation cost. Today, that's all changed.

The cost-competitive TSVision3D system is designed for the high speed, accuracy, and consistency requirements of bin-picking applications. Cycle time for items to be picked can vary depending on the situation, with typical cycle time of 3 seconds, providing an optimized balance between processing speed and accuracy. If only one workpiece is present per image or per tray, cycle time can be as fast as 0.7 seconds, while an image full of workpieces can still be processed in as little as 5 seconds. The vision system is ideal for applications that need to pick or process any solid objects with uniform shapes, such as food or pharmaceutical packaging, order fulfillment, machining output, or manufacturing component binning. The system should free one or two manual operators from a repetitive, boring, and fast-paced process that can be performed more accurately and consistently through automation.

Before Toshiba Machine's TSVision3D system, three-dimensional vision technologies required extensive expertise and were difficult to use. TSVision3D was developed so that anyone, even with minimal training, can understand and implement it.