



How One Spring Company Uses Robotics as a Competitive Advantage

By Mark J. Stevens

Imagine a robot being smart, agile, and fast enough to grab individual parts out of a bin of cluttered, entangled material and — even more complicated — disentangling interlocked objects in such a way that the gripper ultimately picks up a single object.

That's the feat Pittsburgh-based CapSen Robotics achieved on a factory floor at India Springs Inc., a manufacturer of custom springs and wireforms. India Springs Inc. an intricate, multistep production process which includes forming wire into metal hooks, passing them as bulk material into bins and pressing the ends of them. These hooks are ultimately used in a swivel hook extension spring.

Grasping one hook at a time manually is a time-consuming, monotonous task that used to take skilled workers at India Springs Inc. away from their core tasks for hours at a time. Now moving a single hook out of a cluttered pile and into the press by hand is a thing of the past at the company's factory in Pittsburgh.



3D Vision and Motion Planning Software Achieves Something Novel

In this random bin picking application, disorderly, overlapping metal hooks are picked out of a bin in several complex steps, in which the objects are captured with a camera and analyzed with an image processing system to recognize their orientation. The position of the object and its gripping points are then communicated together with the optimal movement to the robot, which then sends the gripper arm on its way.

Since several hooks lie randomly on top of each other, a decision must be made as to which object is the easiest to grasp, especially considering that many of the hooks are only partially visible. If the parts are entangled with each other, it is particularly difficult to grasp a single object,

because there are many possible combinations of interlocked objects. Complex rotations of the object are often necessary, as well as putting the part down and picking it up again in order to grasp it in the right place with the proper orientation. It is often not possible to force cluttered objects into oriented, graspable positions by shaking them or using methods such as magnetic interference. This is where CapSen Robotics comes in.

CapSen Robotics' complete CapSen PiC 3D vision software, motion planning and control solution enables precise and quick handling of the five centimeter India Springs Inc. metal hooks. Its complementary CapSen Scan product captures 3D models in minutes, enabling the robot to quickly adapt to new jobs and parts. Expanding on CapSen Robotics CEO Jared Glover's previous Ph.D. research at MIT

for detecting 3D objects in cluttered 3D images, CapSen has developed its own proprietary 3D vision algorithms since the company was founded five years ago. These algorithms combine the best classical geometric CAD-matching techniques with modern machine learning methods to achieve high detection accuracy across a wide range of object shapes, sizes and materials. The company uses the same 3D vision algorithms to detect boxes as it uses to detect tiny nuts, bolts, screws, and in this case metal hooks. It developed a generic programming library called “multi-matrix” to perform computations on sets of matrices. CEO Glover concludes: We optimized an underlying software infrastructure, a multimatrix library to meet the specific needs in machine learning and robotic environments.

Bin Picking Optimization in a Complex Wire and Spring Assembly Process

CapSen’s software is optimized with Cuda, the language in which NVidia graphics cards are programmed. Typical mathematical calculations and their optimization are performed by intelligent use of a GPU about a hundred times faster than would be possible without using the GPU. The system also processes the next image and plans the robot’s path for the next hook at India Springs Inc., while the robot is still occupied with the picking and placing of the previous object. This makes the system even faster because it can parallelize tasks.

But even the best algorithms help little without the suitable hardware and especially the right gripper. CapSen Robotics used a Precise PAVS6 collaborative robot to manage India Springs Inc. first robotic project. Standard, out-of-the-box grippers did not meet the requirements of the project. CapSen was able to execute the integration with a standard SMC parallel gripper motor and its own customized fingers that can pick up the hooks in two different ways.

“We used digital input/output (I/O) to connect the computer to the gripper arm and the sensors and magnets there — and ultimately to integrate them into the overall system at India Springs Inc.,” said Glover. A stable grasp of the India Springs Inc. hooks is not only critical for the picking and disentangling of the parts, but since the hook that remains in the gripper is not necessarily being held on the right side, the gripper places the hook on a peg fixture that CapSen made. The robot then picks up the hook again with the customized fingers, placing it into a press in the proper orientation each time where the end of the hook is flattened to make it somewhat wider than the rest before dropping it into another bin.

“That’s why we had to design the fingers to be able to pick up the hooks in two different ways,” said Glover. After the hook ends are pressed they are brought to another station, where somebody else at India Springs Inc. puts a bead on the end of the hook that was flattened, which gets pressed together with a spring. The bead thus holds the spring in place and the spring



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gets tapered around. The final product is a hook and spring assembly that can be used for many purposes.

“We are already looking to install this innovative CapSen Robotics solution for some of these other parts of the production line too,” said India Springs Inc. owner Richard D. Froehlich.

Combining Geometry With Machine Learning

CapSen’s core strength lies in highly efficient and advanced algorithms for processing geometric data. Before founding CapSen in 2014, Glover spent a decade developing algorithms at Carnegie Mellon University and MIT to advance the state-of-the-art in geometric optimization algorithms for robotics and computer vision, from developing mapping and navigation software for robotic walkers, to software that enabled a Ping-Pong-playing robot to quickly and accurately detect the spin of Ping-Pong balls as well as learn to hit balls with different spins and trajectories effectively.

To achieve the accuracy required on a wide variety of small complex parts, such as the hooks at India Springs Inc., CapSen combined its state-of-the-art geometry algorithms with new techniques in machine learning. CapSen does not use commercially available machine learning and training models such as Tensor Flow. Instead, CapSen went its own way with a machine learning framework that is inspired by deep learning approaches, but uses far fewer parameters than conventional deep learning. As a result, CapSen’s

machine learning models can be trained to recognize a new type of object with very small datasets of only a few hundred images, versus hundreds of thousands or even millions for typical deep learning systems.

Creating a Competitive Advantage

India Springs Inc. has taken the innovative lead in the industry with its robotic cell, creating a high-speed, low-cost advantage, giving us just a small taste of the many areas in which previously linear processes will be parallelized. The results are fewer mistakes on the production line, less downtime and safer working conditions for employees who can now concentrate on less mundane tasks, leading to higher output, better performance and quality. To view video of robotics usage at India Springs Inc.



Mark J. Stevens is the director of business development for CapSen Robotics. He has more than 25 years of experience with business to business manufacturing and software companies in Germany and the United States, most recently with a focus on robotics and vision systems. Steven’s goal is to understand customer needs and align CapSen Robotics’ 3D vision system capabilities with them to create customer benefits while growing the company brand. For more information, visit <http://www.capsenrobotics.com>.



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