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Credit: Sharon Spielman

Picking Precision:
Advantages of Robotics in Agriculture

To address the challenges of harvesting strawberries—not enough labor, ripeness accuracy, pick quality and food safety—Harvest CROO Robotics has been designing and manufacturing a modern engineering marvel.

By Sharon Spielman

With an ever-increasing global population, the agricultural community can no longer rely on human-only cultivation and harvesting for the current and future demand for food. Machine harvesting has been commonplace in grain-based fields for decades, but the challenges of picking fruits and vegetables have their own unique set of challenges.

"The project is continuously driven because of the difficulty of finding harvesting labor," said Bob Pitzer, co-founder, CTO and engineering manager at Harvest CROO Robotics LLC. "Strawberries are one of the most labor-intensive crops, and if an automated way of harvesting them is not deployed soon, the berries will go back to being a luxury item unavailable to the majority of people."

Sharon Spielman

Bob Pitzer, co-founder, CTO and engineering manager at Harvest CROO Robotics LLC, posed for a picture during Machine Design's visit to learn about the robotic strawberry harvester that is being developed.

To address these challenges, Harvest CROO is transforming agriculture with technological advancements, cultivating the way for increased efficiency and productivity. Along with funding from the strawberry growers in central Florida, the company has developed a 12.5-ton connected, integrated, automated robotic strawberry harvester. This I had to see, so I took a ride out to a Wish Farms grower, G&D Farms in Duette, Fla. There, Pitzer and his team were running tests on the pre-production robotic picker and graciously showed me around.

AN IOT AG SOLUTION IN THE (LITERAL) FIELD

In the expanse of commercial and organic strawberry fields, controlled factory automation met an expansive mobile system. "The whole harvester is an IOT device," said Pitzer, as he pointed to the slow-moving large rectangular vehicle off in the distance. Unlike traditional six-axis robots confined to specific tasks in controlled environments, the robotic harvester faces the complexities of delicate strawberry picking amidst the vibrations of a moving platform.

Sharon Spielman

Unlike traditional six-axis robots confined to specific tasks in controlled environments, the robotic harvester faces the complexities of delicate strawberry picking amidst the vibrations of a moving platform.

"The harvester needs to be fairly nimble to navigate existing fields," Pitzer said, explaining that the farms aim to use their land efficiently by maximizing plant coverage; therefore, a large machine must operate within the confines of the existing truck pathways on the farm for navigation. "The harvester is four-wheel steer/drive to accomplish this and can spin on its wheelbase of 20 feet," he said.

Inside the harvester, on the upper deck, strawberries that have been selected using proprietary technology and then robotically picked are conveyed up, sanitized and kept at a cool temperature for food safety and improved shelf life. (Credit: Sharon Spielman)

Designed with efficiency and maintenance in mind, the machine operates on a diesel-electric setup akin to a train locomotive, with a large generator powering electrical motors for smoother, maintenance-free operation, Pitzer explained as we walked alongside the huge harvester. He said that for a machine intended to run 24/7, the choice of electricity over hydraulics ensures reliability and cost-effectiveness in the long run.

The heart of the robotic picker lies in its meticulously designed control system. Pitzer explained that the air cylinders are used to neutrally float the pick deck, which supports the weight of the 16 robotic arms and keeps them durable and robust. The balancing systems, including spring setups on the robots and mechanical adjustments, ensure precise positioning and reduce strain on the servo motors. Pitzer says that by incorporating spring balancing and other mechanisms, the machine optimizes energy usage and reduces heat buildup in the electrical components.

Sharon Spielman

The harvester must operate within the confines of the existing truck pathways on the farm for navigation.

The machine's cooling system, which is reminiscent of refrigerator trucks, plays an important role in ensuring the freshness and cleanliness of the harvested strawberries, Pitzer says, noting that the harvester can hold up to 10,000 lb. of picked berries. A chiller system cools the water circulating through the tanks, which is necessary for sterilizing the berries and maintaining food safety standards. Unlike human labor, robots eliminate the risk of disease transfer and ensure a higher level of cleanliness by using quick disconnect parts that can be easily replaced and sanitized. This meticulous approach to handling berries not only reduces the chances of contamination but also spoilage.

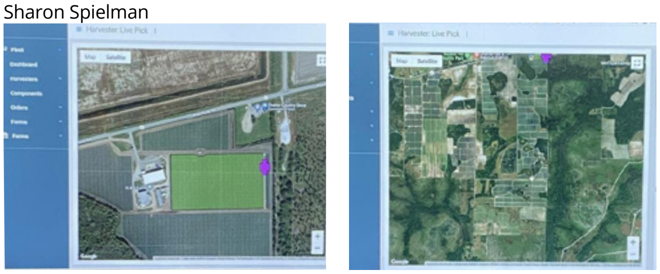
The integration of advanced technologies like sensors and AI enhances the performance of these robots in selective harvesting, where delicate fruits are carefully picked without damaging surrounding produce.

ROBOTIC PICKERS: FROM CONCEPT TO FRUITION

The journey of conceptualizing and implementing these robotic pickers dates to 2013, Pitzer said, when the initial experiments were conducted. Harvest CROO, a sister company to the farm, spearheaded this endeavor funded by major players in the strawberry industry. Through years of research and development, the team has secured multiple patents for their innovative systems, establishing a new standard in agricultural automation. The robots' ability to scan plants, create 3D models and navigate precise paths for picking displays the level of technological sophistication that has been achieved in this field.

The data collection and analysis capabilities of these robotic pickers are vast with servers storing terabytes of information for real-time monitoring and decision making, according to Pitzer. The software integrated into the system enables farmers to track harvest progress, analyze crop performance and optimize harvesting strategies. Utilizing cutting-edge technologies like artificial intelligence (AI) and cloud computing, these robotic pickers have transformed traditional farming practices by enhancing efficiency precision and data-driven insights.

Sharon Spielman



The harvester uses LiDAR technology and differential global positioning systems (DGPS) to do all its navigation and enables the harvester to be tracked in real time.

The harvester uses LiDAR technology and differential global positioning systems (DGPS) to do all its navigation. "The GPS provides the waypoints and plant locations and the LiDAR detects the anomalies and farm accessories to be able to navigate the harvester around autonomously," Pitzer explained. "It's not fast, so collision avoidance and the pre-configured farm make navigation relatively simple compared to autonomous cars, etc.," he said.

Using advanced cameras, LiDAR and electric actuators, the robotic harvester can scan, inspect and pick strawberries autonomously. As for the integration of sensors, AI and other technologies used to detect and harvest the ripe berries, Pitzer says the robots and inspection systems also use limited AI and machine vision to pick and inspect the berries, all with RGB cameras. "The robots are positioned to look for the berries in a confined envelope to make the berries easier to find and provide conservation of motion for doing the pick-and-place for pulling the berries off the plants in an economical fashion," he said. "Ripeness is done in a proprietary way, and all the hardware is custom to handle the delicate fruit."

Over an 11-year span, the project has seen technological advancements and strategic partnerships with manufacturers, inching closer to producing harvesters at a viable rate, Pitzer said. By leveraging a combination of Intel Mobius and NVIDIA processors for vision processing and partnering with Festo for component fabrication, the project integrates cutting-edge technology and modular design principles to streamline production processes. "[The system] is cross correlating two cameras to tell you the depth of the strawberry,"—even with all the green that surrounds the plant, measuring the fruit bed within a couple of millimeters, Pitzer said. "We don't damage [the plant]…you couldn't do that on a single-processor system [before]," noting that much more powerful processors are being developed every day.

CULTIVATING A BUSINESS PLAN, NURTURING THE FUTURE

To deploy thousands of harvesters effectively and work with farms that are accustomed to traditional labor practices, a strong infrastructure is necessary, Pitzer said. This collaborative effort not only ensures scalability but the goal is to foster partnerships with industry stakeholders (think John Deere and Caterpillar). Pitzer adds that the business model of leasing the machines to farms offers a sustainable approach to introducing robotic harvesters.

The machine is in its testing and refinement phase, using data collection and feedback to improve performance. The harvester knows all the plant positions, so that gives it the ability to collect information about individual plants, Pitzer explains. "Many metrics are collected related to berries on the plant and any forecast information that can be accomplished like counting blooms or counting unripe berries. It is a large data collection machine," he said. "This information is constantly analyzed to improve robot performance and is going to be used in the near future for reinforcement training of the robot movement to improve."

Sharon Spielman

The team is able to capture and monitor all aspects of the harvester and its cultivating process using its dashboard—from how many berries were picked by each robot to whether or not the berry was ripe enough to pick or if there was even an attempt to pick.

As for how Pitzer foresees the role of robotics technology evolving in the agricultural industry: Manipulating robotics will first impact fresh fruits and vegetables. "Most people don't realize that 90% of what they pull out of the produce section of the grocery is still hand-picked," he said.

Some crops make more sense than others do initially because of the way they have to be harvested, Pitzer explained. "Strawberry plants are picked ~40 times during a growing season and account for 50% to 60% of the overall farm cost for growing the strawberries," he said. "It's a very expensive crop to harvest, therefore the cost of the automation can be justified. As this technology matures, it will reduce in cost and make sense to migrate to other crops."

FROM CHALLENGING COMPETITION TO AGRICULTURAL PROBLEM-SOLVING

During a visit to G&D Farm in Duette, Fla., Bob Pitzer, co-founder, CTO and engineering manager at Harvest CROO Robotics, spoke of the impact that the FIRST Robotics Challenge has had on endeavors such as the robotic strawberry harvester that the company and the strawberry industry has been designing and manufacturing for more than a decade. The competition has helped foster young talent in engineering and innovation, he said.

Originating in 1994, the FIRST Challenge involves teams constructing large robots to compete in various tasks. Behind the scenes, mentors and professionals focus on integrating lights, wires, software and infrastructure to ensure smooth event operations, allowing students to highlight their robot designs effectively.

Pitzer talked about the pivotal development that surfaced in 2009 when advancements were made to enhance robot capabilities through Wi-Fi control systems, challenging conventional beliefs about real-time control using Ethernet and Wi-Fi. Collaboration with industry leaders like National Instruments and Cisco drove the integration of networked robots, he said, setting the stage for students to engage in practical engineering tasks. The growth of the first robotics challenge, from 600 teams in 2006 to more than 8,000 teams today, underlines the impact of technology and mentorship in nurturing the next generation of innovative engineers and problem-solvers.

Courtesy Carbon Robotics

The Vision of Sustainable Agriculture:

Laser-Focused on a Weed-Free Farm

Carbon Robotics' LaserWeeder uses artificial intelligence, an advanced vision system and laser technology for sustainable weed management and agricultural productivity.

By Sharon Spielman

When it comes to sustainable agriculture, the challenge of finding effective weed management has led to some groundbreaking technologies. Carbon Robotics' LaserWeeder stands out among them, using cutting-edge computer vision and artificial intelligence (AI) to address the never-ending need for weed control in agriculture.

Founded in 2018, the company began with a vision to integrate advanced technology with traditional farming methods. Paul Mikesell, CEO, brought with him expertise in AI and robotics, translating insights gained from discussions with farmers to actionable solutions. His goal was clear: Harness Silicon Valley innovation to tackle region-specific agriculture issues that have been overlooked through the years.

THE ROLE OF TECHNOLOGY IN SUSTAINABLE AG

At the heart of the laser weeding machine's functionality is its sophisticated vision system. Using real-time data processing, the machine leverages deep learning models to distinguish between crops and weeds. This is accomplished through an array of cameras integrated with an AI-driven neural network, which continuously assesses its environment, making on-the-fly predictions and classifications.

Unlike traditional object detection algorithms that rely on contours and edge detection, the LaserWeeder's neural networks are designed to comprehend higher-level plant characteristics, allowing for adaptive responses to varying soil conditions and environmental factors.

The application of high-powered lasers for weed eradication offers a shift in agricultural practices. By targeting weeds directly and avoiding the need for herbicide usage, the machine eliminates the risks associated with chemical exposure for farmers and consumers alike. This method not only preserves the integrity of the crops but also minimizes environmental impact.

Mikesell highlights two primary benefits of the laser technology: enhancing crop yield and reducing dependency on fertilizers and water, as the plants experience less stress from chemical applications.

"It doesn't knock your crops back, right, because if you're not spraying herbicide, you're not damaging your crops." Mikesell said, noting that farmers also need less fertilizer and water to grow crops. He added that because blades are no longer being dragged to the ground, torn-up topsoil isn't causing erosion.

Courtesy Carbon Robotics

The ability to distinguish between crops and weeds is accomplished using an array of cameras integrated with an AI-driven neural network, which continuously assesses its environment, making on-the-fly predictions and classifications.

SYSTEM PERFORMANCE AND REAL-WORLD CHALLENGES

Operational efficiency is built into the machine's design. The LaserWeeder navigates fields at a rate of approximately 1 to 2 acres per hour, an effective speed for thoroughness that also can be adapted to the weed density in the fields. The effectiveness of the vision system is demonstrated through key performance indicators (KPIs), which aim for more than 90% accuracy in weed identification, while ensuring that crop misidentification remains below 1%.

Before bringing the machine to market, Carbon Robotics engaged in extensive field testing from 2018 to 2022. This phase revealed the many environmental challenges that agricultural robotics must overcome such as heat humidity and dust.

"By the time we had machines to market, we'd been through several different generations of [the] machine—everything from the type of optics and servos to the type of GPUs and the types of neural nets that we were using," Mikesell said.

These rigorous field trials were important, he said, due to the unpredictable nature of outdoor conditions. The commitment to real-world application ensures that the laser reader performs consistently in a range of settings.

"I think people have a tendency to try stuff in the lab and then never get it into the field," Miksell said.

Courtesy Carbon Robotics

The LaserWeeder's KPIs aim for more than 90% accuracy in weed identification, while ensuring that crop misidentification remains below 1%. There have been several iterations of the machine since the company was founded in 2018.

ROI, FUTURE OUTLOOK AND SCALABILITY

From an economic perspective, the company aims for a return on investment (ROI) for farmers that allows for payback within one to three years of equipment purchase. Yield increases of up to 50% have been reported, which demonstrates the machine's effectiveness for eliminating unwanted vegetation. By reducing herbicide reliance, farmers can gain insights into the extent of damage previously done to crops by chemical applications.

With regard to finding reliable suppliers for the integration of advanced components in the machine, Mikesell says that the company collaborates with several companies worldwide to ensure they source the best parts. This multi-sourcing strategy guarantees quality and reliability in the system's components, he says.

As Carbon Robotics looks to the future, Mikesell says they are creating a new, unrelated product line that will be released later this year.

When asked if the Average Joe would have access to this type of weed eradicator for the backyard, Mikesell said, "[If somebody] wanted to produce a consumer version, we could maybe license some of the software or something, but that's a different business than what we focus on," he said. Carbon Robotics' focus remains on business-to-business (B2B) solutions.

For now, the company is concentrated on refining its current LaserWeeder model while exploring potential expansions in equipment size and functionality in response to evolving agricultural needs, helping to provide a sustainable pathway toward the future of farming.

Courtesy OnRobot

Combination of powerful FANUC CR-35iB cobot and customizable OnRobot 2FPG20 finger grippers offers "game-changing" solution for heavy-duty agricultural palletizing, at a third of the cost of traditional palletizer.

Heavy-Duty Collaborative Palletizing System Addresses Potato Industry's Labor Shortages

A limited labor pool compels a potato farmer to think outside the box. The solution? Two rugged electric finger grippers mounted to a cobot arm that handle the 52.5-lb boxes.

By Kristian Hulgard

Dean Gibson's family has been producing and packaging potatoes for generations from the heart of Idaho's prime potato-growing region.

"One of our biggest challenges absolutely is labor, especially on the palletizing line," said Gibson, co-owner and controller of Magic Valley Produce.

The company operates from a low-slung building that has changed little since its founding in 1964. With 42 employees, Magic Valley is by far the largest employer in the town of Paul, population 1,441. Many of Magic Valley's employees have been with the company for more than three decades, and the average age of the palletizing workforce is now 63 years old. As those valued workers begin to retire, there is a limited labor pool to replace them.

Currently, Magic Valley stacks eight pallets at a time, with four to six people working full time, year-round lifting 52.5-lb boxes over their heads for the top layers. With a robot able to stack two pallets at a time, a single supervisor could easily manage multiple pallets with a lower possibility of injury.

"Our goal was never to replace anybody, but with an aging workforce, and it being harder to find people all the time, it's just become more of a necessity," Gibson explained. "That was one of our biggest fears moving forward."

OnRobot

Heavy (52.5 lb/23.8 kg), two-piece boxes with slip top create palletizing challenges, as traditional vacuum grippers would pull the top off rather than lift the box.

The strain on the labor pool is especially true of the palletizing line, which is critical to getting product out the door. "As people retire, and as things change, I just need to have options, and this is definitely a huge part of having options going forward," he said.

Gibson researched his options and discovered three major challenges to automating the palletizing line. First, the building itself has little available floor space and overhead space, making it difficult to find a robot small enough to fit into the existing production floor. Second, the boxes are too heavy for most collaborative robots that could fit the space.

The third challenge proved to be the most difficult: The potatoes are packed in two-piece boxes with an unsecured slip top that makes it impossible to use traditional vacuum grippers, which would pull the tops off the boxes rather than lift them.

OnRobot

Two OnRobot 2FPG20 electric finger grippers are mounted side-by-side, customized with curved fingers on one side to tuck under one side of the box with 40 nanometers of force, compress the box, and lift it.

DUAL FINGER GRIPPERS AND INDUSTRIAL-STRENGTH COBOT SOLVE SPACE AND WEIGHT CHALLENGES

Despite its tight quarters, Magic Valley packages 100 million pounds of potatoes a year, sorting them by size into 52.5-lb boxes (23.8 kg) for restaurants and food producers. Those boxes are then palletized up to seven layers high—more than six feet (1.8 m). Magic Valley produces 150 pallets per day, with almost a ton of potatoes per pallet.

Gibson was skeptical that a small, powerful and dependable palletizing system existed that would meet those demanding requirements. But when John Weeks, CEO of automation integrator WeAssistBots, walked through Gibson's facility, he was confident he could meet the challenge. Weeks chose the FANUC CR-35iB cobot, with an industry-leading payload of 35 kg (77 lb) and reach of 1831 mm (74 in).

"It brought the horsepower required to do 50-lb cases in the Idaho potato industry, that up until now a traditional cobot couldn't touch," Weeks explained. The cobot also combined the small installation footprint and large work envelope that Magic Valley needed. The cobot can stack two pallets at once (one on either side of the robot), reaching easily from floor to ceiling, and actually taking up about 18 fewer inches than having workers in that area.

In an innovative approach, Weeks mounted two rugged OnRobot 2FGP20 electric finger grippers on the cobot arm to handle the 52.5-lb boxes. This approach doubled the tool's individual payload of 20 kg (44 lb).

Weeks credited the quick response from OnRobot's technical team to make the integration work. When he and his engineers encountered some hiccups with mounting the dual tools, he called his OnRobot contact and received immediate technical support. With the additional information, Weeks and his team of engineers were able to make the appropriate adaptations for a successful deployment.

OnRobot

Robust, proven finger grippers provide the power necessary to lift heavy boxes and to nudge them into place for pallets stacked up to seven layers high.

ONROBOT ADAPTABILITY AND CUSTOMIZABILITY SOLVES GRIPPING CHALLENGE, INSPIRES CONFIDENCE

With the weight and footprint issues addressed, the slip-top box challenge required additional innovation. According to Weeks, that's where OnRobot really shines. "My favorite thing about OnRobot tooling is absolutely their adaptability and the customizability," he said.

Weeks attached a metal plate with curved fingers on one side of the dual grippers, then programmed the robot arm to angle the tool so it tucks the curved fingers under the bottom of the box before lifting it. "With the customizability of the 2FGP20 versatile tooling, we were able to get both finger grippers underneath the edge of the box with 40 nanometers of force, compress that box, and deliver it gently and quickly and safely," he explained.

"Before, you always had to make your own custom tooling, and you had to hope that it would work," Weeks said. But with a proven, warrantied and immediately available OnRobot gripper, Weeks pointed out that the company now has a single tool that "is off-the-shelf ready, tried-and-true tested, and will literally do the job over and over and over again without any interruptions."

Gibson credits the OnRobot tooling for the palletizer's success. "The gripper in particular is what made the whole system come together because it was crucial to keep the two-piece, 52.5-lb box together, and be able to pick it up and place it," he said. "That is the only reason why this all worked for us, and that's to John's credit and to OnRobot for being able to collaborate and make that happen."

OnRobot

Industrial-strength FANUC CR-35iB cobot fits in space-constrained work envelope with limited headroom and footprint.

COLLABORATIVE PALLETIZER IS SMALLER, MORE VERSATILE, AND COSTS A THIRD OF THE PRICE OF TRADITIONAL SYSTEMS

Magic Valley's palletizer is a prime example of a new wave of powerful collaborative applications, making automation viable for smaller agricultural producers.

In an earlier automation effort, Gibson had invested in a traditional palletizing system to handle large bags of potatoes that are packaged for retail sales. While the system worked well for that process, it required a huge footprint at one end of the facility for the dedicated conveying system and palletizer, as well as the required large safety cage. And the system could only palletize one product line, compared to the smaller and more versatile collaborative system.

"The more traditional systems are a lot more expensive, Gibson explained. "They take up a ton of space and they take up a lot of money, too." Comparing the new collaborative palletizer to more traditional systems, he said this system is about a third of the price. "And that's a game-changer for me; it's so much more cost-effective, and ROI is so much better than any other options that were out there."

Gibson said there are many facilities in the potato industry that are both older and size-constrained. An automated plan could provide a cost-effective option, he said.

OnRobot

Collaborative palletizing system takes up less space than manual workers doing the same job, without the cost or size and safety caging required with traditional automation.

AUTOMATION PLAN INCLUDES MORE ONROBOT-POWERED PALLETIZERS, PROVIDING OPTIONS FOR ALLEVIATING LABOR SHORTAGES

Weeks has worked with Gibson to develop an automation plan that Magic Valley can confidently deploy over time, using the collaborative palletizing solution with the FANUC cobot and OnRobot tooling along with new optical sorting systems.

"With the three to four robots in staging and everything that we're going to have to do to make it all function, it is still a fraction of what some of these other systems are," Gibson said. "And going back to floor space, this is really hands-down the best option for us."

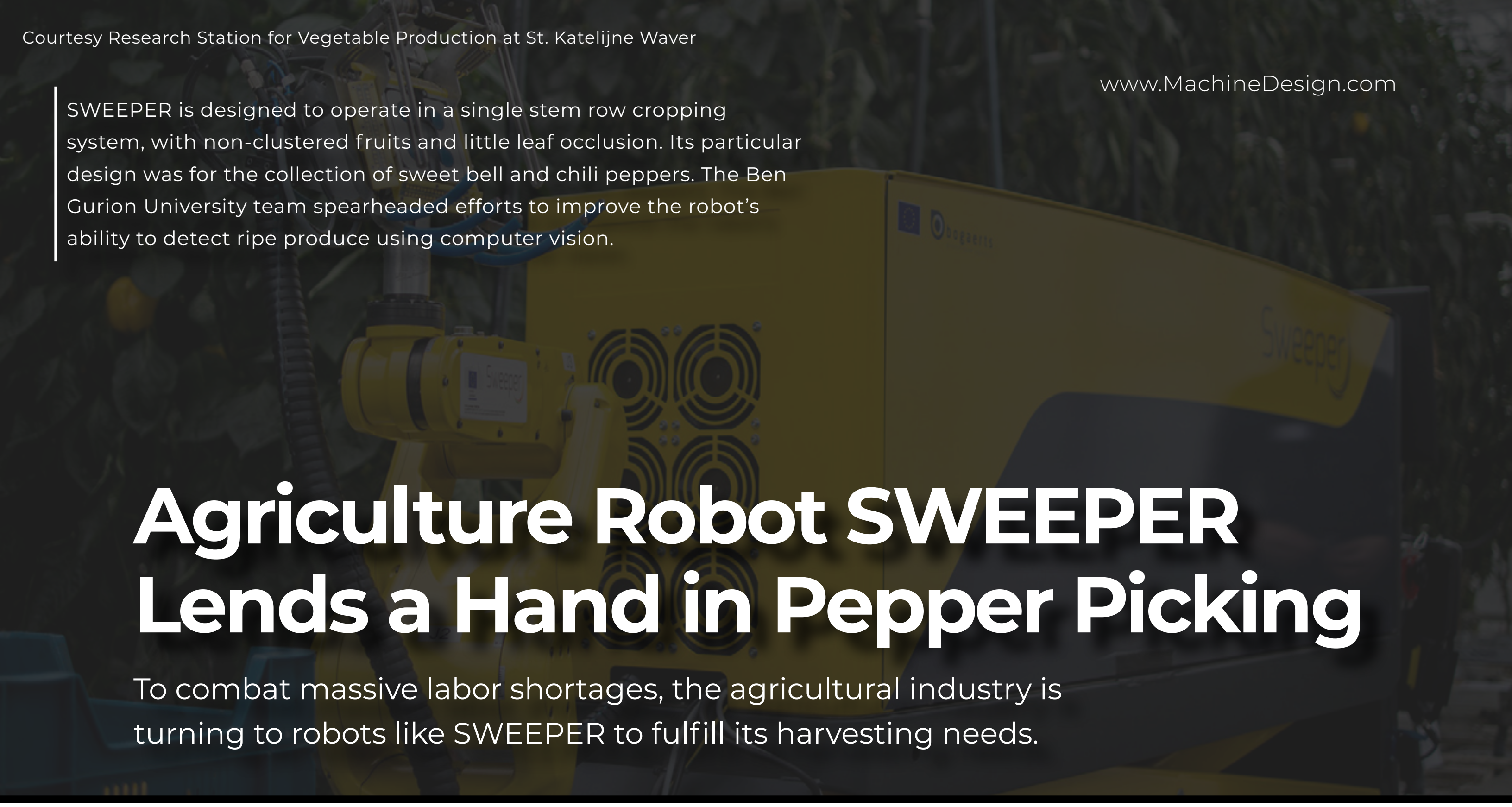
Automation also offers new opportunities for employees and more attractive positions for hiring and retaining workers. Gibson viewed finding people who are willing and able to work with automation as an additional challenge. But while some of his workers initially felt intimidated by the equipment, others have stepped up to learn how to use the technology and run the new systems, increasing their value.

"The more automation that you know how to run, the more secure your job is," he noted.

Now lead robot technician, Jose Santa Cruz recollected being nervous when he first learned to use the application. "But it's all kind of common sense; it's like a computer," he mused.

Santa Cruz said he had seen family and colleagues with back injuries from manual labor. "I can see how this could stop all that," he said. "People would be healthier. I think there's going to be more opportunities for me in the future."

Kristian Hulgard is general manager of OnRobot Americas.



Courtesy Research Station for Vegetable Production at St. Katelijne Waver

SWEEPER is designed to operate in a single stem row cropping system, with non-clustered fruits and little leaf occlusion. Its particular design was for the collection of sweet bell and chili peppers. The Ben Gurion University team spearheaded efforts to improve the robot's ability to detect ripe produce using computer vision.

Agriculture Robot SWEEPER Lends a Hand in Pepper Picking

To combat massive labor shortages, the agricultural industry is turning to robots like SWEEPER to fulfill its harvesting needs.

Finding efficient, affordable labor to pick and sort crops has long been a problem for the agricultural industry. This past September saw the introduction of a robot called SWEEPER for picking sweet peppers—the industry's newest attempt to ease its labor burden via automation.

The robot was developed by a consortium between BGU, Wageningen University & Research, and pepper grower De Tuindershoek BV in the Netherlands; Umea University in Sweden; and the Research Station for Vegetable Cultivation and Bogaerts Greenhouse Logistics in Belgium. The SWEEPER project has received funding from the European Union's Horizon 2020 research and was introduced at the research station for vegetable production at ST. Katelijne Waver in Belgium.

SWEEPER was designed to operate in a single stem row cropping system, with non-clustered fruits and little leaf occlusion. Within these conditions, the robot can harvest ripe fruit in 24 seconds with a 62% success rate. The BGU used advanced computer vision methods to improve the robot's ability to detect ripe produce, which has determined the robot's hardware and software interfaces.

According to Polina Kurtser, a Ph.D. candidate in BGU's Department of Industrial Engineering and Management, using robots to harvest fruits and vegetables will revolutionize the economics of agriculture industry. "The Sweeper picks methodically and accurately," she says. "When it is fully developed, it will enable harvesting 24/7, drastically reduce spoilage, cut labor costs,S and shield farmers from market fluctuations."

The market for robots in agriculture has been on the rise, primarily due to the aforementioned labor issues. According to a survey conducted by the California Farm Bureau Federation, 55% of farmers have experienced employee shortages. To combat the lack of labor, two-thirds of farmers surveyed reported using or starting to implement some form of mechanization into their production process.

Earlier this year, Agfunder News reported that the harvesting robotics market reached $5.5 billion from early adopters alone. In a market research report conducted by Alpha Brown, this market share only represents 3% of the growers, mainly local and independent farmers. The report showed that 27% of the 1,300 growers surveyed are considering purchasing a robot to help with their harvesting needs. Their main concerns are time-saving and efficiency to ensure an on-time harvest.

For SWEEPER, more research needs to be conducted to increase its speed and harvest success rate. Following the latest test results, the researchers behind it expect the robot to be commercially available with the next four to five years. This would be a boon to farmers in North America, the second largest producer of sweet bell and chili peppers in the world with 31% market share. Europe accounted for more than half of the world's pepper supply at 53.2% market share.

Courtesy Danfoss

Grape Harvesting is Ripe for Improvement

Self-driving carts in California's farming industry show great promise.

Slowly, silently, effortlessly. The autonomous grape cart does not necessarily attract much attention as it drives through the rows at Parminder Brar's 900-acre family farm in Kern Country, Ca. But it has a big effect.

Parminder has volunteered to test the cart at his table grape farm this harvesting season. And his verdict is clear: The cart not only makes the workday for his seasonal employees a lot easier, but also drives up productivity.

With the cart between the rows, more human hands can focus on picking. They simply fill up the autonomous cart with boxes full of ripe table grapes as it passes.

Danfoss

"We often have difficulties hiring enough qualified pickers during the harvesting season. Most growers experience this. Autonomous grape carts will help us fill this shortage of workers gap," said Parminder Brar.

GOODBYE BUMPY RIDE

This marks a big difference compared to the traditional method, where members of each picking crew collects the grapes in a wheelbarrow which is pushed through the rows.

"The rows are 100 meters long. Pushing the wheelbarrow is a dusty, sweaty job eating up a lot of time which this cart enables us to spend picking grapes instead," said Brar. "We have six picking crews working in teams. If we had three or four carts for each crew, we would get a huge productivity boost." Brar added that the carts seem robust and reliable easily navigating around any obstacles.

The carts, brand-named Gopher IQ, fulfill California startup Vinergy's goal: to increase profitability for farmers of hand-picked specialty crops, including table grapes, blueberries, peppers and other produce by using rechargeable electric machines. The company was founded in 2019, launching a semi-automatic version of the cart the same year. Now they are about to hit the market with the self-driving version—one of the first-ever autonomous vehicles in the specialty farming market.

Danfoss

"We are very satisfied cooperating with Berendsen Fluid Power and Danfoss," said Justin Meng. "The functionality and robustness of the control system they have designed is phenomenal."

"We are very satisfied cooperating with Berendsen Fluid Power and Danfoss," said Justin Meng. "The functionality and robustness of the control system they have designed is phenomenal."

"I am extremely proud. With our Gopher IQ cart, we can improve productivity for an average picking crew as much as 30%," said Justin Meng, president and CEO at Vinergy. "This translates into real savings for the farmer. It also frees up available hands. And this is key right now as farmers across the U.S. wrestle with labor shortages and rising wages."

The plan is for the carts to be available on a rental basis for a monthly fee that includes service. Vinergy aims to have the first 60 to 75 carts available next harvesting season and to ramp up from there.

Danfoss

At the end of the row, the autonomous cart quietly turns 180 deg. and drives into the next row. When the cart is full, members of the packing crew empty it, then send it to work again.

CONVERTING SENSORS TO SOLUTIONS

Vinergy teamed with Berendsen Fluid Power to design the cart's electric drive and control system, which includes components such as batteries, electric motors and advanced sensor technology.

Danfoss supplied the intelligent display DM1000 that includes a powerful computer with the Danfoss PLUS+1 Guide software inside. The software was customized to fit Vinergy's needs. The computer and software together make up the digital brain converting sensor signals to physical movements, thereby enabling the cart to navigate the grape rows autonomously.

"The software part of autonomous driving is difficult. Reliability and safety are incredibly important. It is relatively untrodden territory, and few companies master it. Danfoss does," said Mike Kelly, mobile sales director at Berendsen Fluid Power. "Partnering with them, we were able to bring this solution to market fast. And we are ready for a ramp-up."

The cart is equipped with a LiDAR (Light Detection and Ranging) sensor with a 270-deg. field-of-view. The sensor uses laser light to monitor the area in front as it drives through the grape rows. If an obstacle or person is detected, the cart automatically finds a way around. If it cannot detect an alternative path, it stops. The PLUS+1 Guide software and the computer inside the DM1000 display constantly process sensor signals converting them to physical movements of the cart.

Vinergy already has several customers among fruit growers across California using its semi-automatic grape cart—and are negotiating with potential ones in Mexico and Peru. A handful of California

Mike Kelly

farmers are currently testing the autonomous version, including Parminder Brar.

"We are impressed by the cart's effectiveness and plan to lease several of them next harvesting season," he said. "There is no doubt in my mind that autonomous machines will play a growing role at our farm in the future."

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This article appeared in [Power & Motion](#).