Technical White Paper

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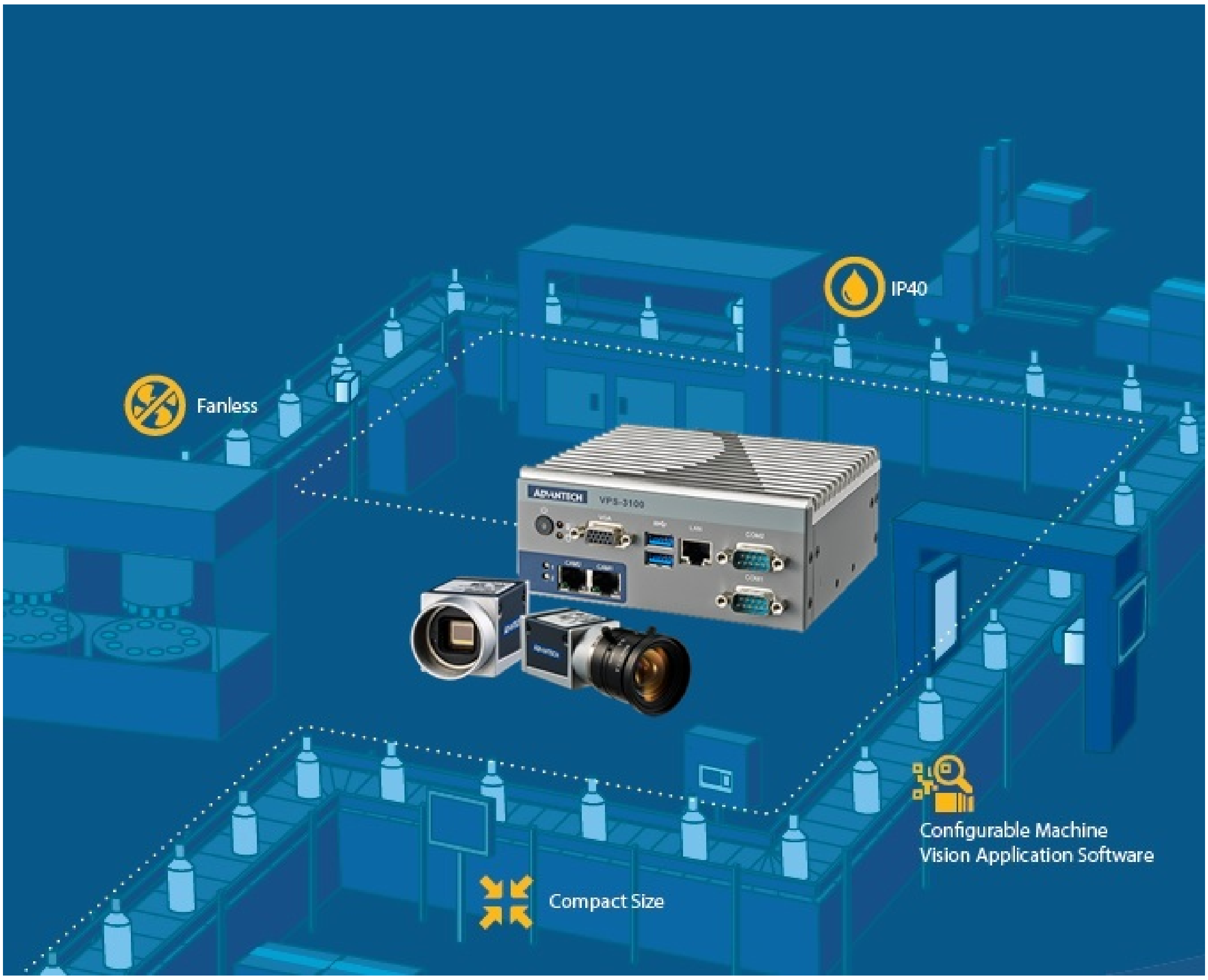
Solution-Ready and Scalable Platforms Simplify Machine Vision

Developments in scalable embedded hardware and accompanying software have advanced machine vision from a specialized inspection tool into a powerful, flexible, and cost-effective automation solution.



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For many decades, advancing technology has enabled machine vision to serve a growing role within the portfolio of industrial automation system technologies. The earliest implementations simply detected presence, while the most recent “smart camera” iterations are far more capable. Machine vision is especially well suited for repetitive high speed inspection of parts and assemblies, and for analyzing conditions to ensure they meet demanding specifications.

Due to high computational demands and the intricate nature of dissecting and scrutinizing high speed images, the hardware platforms involved with machine vision systems were often specialized and required equally complicated software. Implementing these systems was typically considered a highly-customized task, increasing acquisition, installation and maintenance costs.

The latest class of machine vision platforms is poised to reduce these costs by simplifying the implementation of powerful machine vision capabilities. Scalable “plug and play” embedded hardware is simple to install, compliant with industry standards, and offers exceptional power. Correspondingly, an easy-to-use software graphical interface exposes all the machine vision features to users to facilitate initial development, as to simplify future maintenance and modifications.

These user-friendly machine vision platforms make the technology accessible for today’s applications and scalable for tomorrow's opportunities. Solution-ready packages not only help end users succeed technically, but also represent the most cost-effective approach. This white paper will describe how new scalable machine vision platforms are the right answer to help solve customers’ automation and manufacturing challenges.

Where Machine Vision Excels

Machine vision has evolved rapidly over the past several decades as complementary technologies have improved. Fast, high-resolution digital image capturing, ample PC processing power, and sufficiently capable image handling software all had to be combined to achieve useful systems.

Even when systems in the 1980s were capable of recognizing labels and two-dimensional symbols, there remained significant challenges. The objects being inspected often had to be carefully aligned to present a repeatable image, and lighting had to near perfect. Early generations of software were complicated to configure and limited in capabilities.

However, when these limitations were overcome, machine vision could excel in high-speed inspection applications. These types of tasks are repetitive and tiresome for humans to perform, not to mention the fact that people have a high error rate in these situations.

Machine vision provides the ideal solution for this form of inspection work, and can also maintain a photo record for quality purposes. Users typically discover automated optical inspection (AOI) to be by far the preferred quality control method compared to human inspections.

The latest “smart camera” systems offer even more advanced analysis capabilities, including 3D. In these cases, machine vision offers options no other sensing technology can provide, such as computing the volume of an inspected target. Machine vision is in the news weekly for applications in drones and driverless cars.

While 2D imaging has been the established technology for many years, advances in 3D imaging will begin supplementing and even superseding 2D. In addition, vision platform advances and cost declines are opening up machine vision technology to complement other fields, especially robotics.

As *AutomationWorld.com* puts it, “Traditional use of robotic vision has included mainly finding a target to build on, such as a printed circuit board (PCB), or for bin picking or reorienting parts.” Continuing, “But use has been expanding as vision becomes cheaper and more accessible. That includes letting a robot decide what it will do … vision systems can make those decisions”.

Clearly, machine vision systems offer many superb advantages. While image processing and computing capabilities will continue to increase, there remain many challenges for typical end users wishing to deploy these systems.

Challenges with Existing Solutions

Machine vision hardware and software has historically been complicated and challenging to engineer and integrate. This increased the element of risk for end users considering these systems, as well as the cost. This section will expand on the challenges with existing machine vision solutions as listed in Table 1.

<u>Table 1, Challenges with Existing Machine Vision Solutions</u>

- Expensive to acquire
- Hard to integrate with other automation system components
- Performance limitations in terms of speed, object recognition, etc.
- Difficult to program
- Not scalable
- Hard to engineer, maintain and modify

Industrial automation hardware such as controllers and sensors never comes cheaply, even though some components are less expensive than others. Devices used for industrial automation sell far fewer quantities than common consumer goods, and must be built to operate for many years in harsh environments, and both facts drive up prices.

However, even within the realm of industrial automation, machine vision has been somewhat of a specialty.

Machine vision components have traditionally been relatively expensive, and many times have required a high level of pre-engineering to specify. The installations demanded careful attention to orientations and lighting. Vision systems could be very effective, but there were no shortcuts to achieving functionality.

As with other specialty analytical sensing systems, vendors concentrated first and foremost upon the sensing technology. Even with a properly engineered and functioning system, the primary focus of a vision platform was more on the vision functionality, and less on the integration with other systems. Communication interfaces were still evolving, and oftentimes vision systems were installed as standalone islands, performing their function exclusive of other automation in the area.

Until recent years, performance was always a concern. There was not always enough image resolution and processing power to adequately recognize objects with the desired speed. As we will see shortly, consumer electronics trends have improved technology in a way largely eliminating these types of performance worries today.

Even when end users could obtain the right hardware and install it as needed, the next hurdle could be even larger – how to effectively program the machine vision system. These specialty systems were stretching the hardware to the limits, and the accompanying software was often complicated, cryptic and difficult to learn. Many vision systems over the years have been bolted into place and then experimented with for a time, before being abandoned or perhaps superseded with simpler, but therefore less capable, sensing methods.

Available hardware options were typically quite limited. Users often faced making their application fit the capabilities of the vision system, instead of the other way around. With the hardware and software already running at maximum capability, there was no way for vendors to offer the platforms in a scalable manner. The lack of modular options limited the choices for end users, and invariably increased costs.

These challenges often combined to push determined end users into retaining specialty engineering and integration firms to implement vision systems in their plants and facilities. Certainly, there is nothing wrong with relying on trained expertise. However, given the experimental nature of many early vision system endeavors, the added cost of expert talent deterred many users. Also, the ongoing obligation to use a dedicated engineering firm for changes or even basic maintenance was cost prohibitive in many cases.

The first generations of industrial vision systems held a lot of promise and were adopted to great effect by many cutting-edge end users. But the expense, limitations, and difficulty of programming and maintaining these systems also defeated many projects.

For machine vision systems to become truly mainstream, they would need to become easier to use and more powerful, as well as more economical. Some of the required hardware and software improvements for end users would include making the hardware scalable and the software easy to implement.

Performance Requirements for Machine Vision Platforms
Fortunately, several advances in the consumer computing arena have supercharged exactly the technologies required for widespread adoption of industrial machine vision. A few of the key technologies which have progressed in this way over the last decade or so include:

- Proliferation of high resolution digital imagery hardware
- Development of extremely powerful PC and graphics processors
- Software designed with an increasing focus on both flexibility and ease of use
- Exponential growth of high speed networking and large capacity storage
- Standardized protocols

Taken together, these advances truly bring machine vision into the mainstream of automation technologies. They allow users to focus on solving problems and improving operations with vision platforms, instead of worrying about how to make the technologies work. Figure 1 depicts some elements common to a machine vision platform.

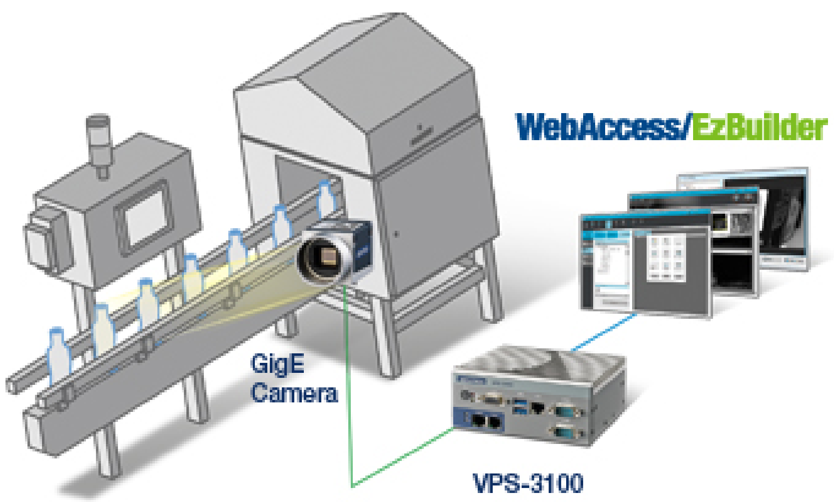

Figure 1

This *ControlDesign.com* article looks at vision solutions as a three-part system. “There are three major components to a vision system—processor/sensor; lighting/lensing; program/interface. Just like a three-legged stool, if one of the legs is weak, the whole thing can falter”.

These three parts could also be loosely defined as hardware, installation and software. End users are well advised to consider these elements closely when selecting a system, and additionally to make sure the overall system is easy to use.

The following paragraphs will explain how the solution-ready features identified in Table 2 ensure machine vision systems have the right performance to get the job done.

<u>Table 2, Machine Vision Platform Solution-Ready Requirements</u>

- Compact ruggedized design provides a wide variety of installation options
- High-availability hardware
- Flexible feature set ensures the platform can accommodate changing requirements
- Integrated functions such as lighting control and I/O
- Dedicated FPGA hardware shoulders the computational load to guarantee performance
- Compatibility with GigE Vision and GenICam
- Intuitive Graphical User Interface ease initial development, and subsequent maintenance and modifications
- Convenient licensing
- Cross-platform compliance with other software packages
- Security

While some vision systems may end up in pristine laboratory conditions, most installations will be located in much more challenging industrial environments. The hardware—including the cameras and the main controller—must be designed to withstand extremes of temperature, vibration, dirt, moisture and electrical noise.

The VPS-3100 offered by industrial automation leader Advantech exemplifies a vision hardware platform meeting just these requirements (Figure 2). In addition, it satisfies many other end user requirements. For instance, users should look for components offering a variety of installation options in a compact package. Fan-less operation and solid state drives are fundamental to establishing high-availability.

Figure 2

A flexible feature set ensures the system meets current requirements and is likely to accommodate future changes. Of course, the controller must have various electrical connectors and would typically be installed in a control panel. Especially important is a wide variety of interface options: camera interface ports, Ethernet port, display port, multiple USB and serial ports, and digital I/O connections. In addition, the capability for the vision platform to natively control strobe lighting is necessary for reliable image captures.

Inside the box, the best performing systems will combine powerful central processing units (CPUs) with advanced field programmable gate arrays (FPGAs), which are tailored to economically providing high-performance image signal processing. This kind of power is needed for real-time transcoding.

Standards Simplify Implementation

Standards usually play an important role when selecting any industrial automation systems, and machine vision platforms are no different. Here, two prevailing standards to look for are “GigE Vision” and “GenICam”. GigE is a set of protocols built on top of standard gigabit Ethernet, optimized to supply the image data and interface with any camera parameters. GenICam is a standardized application programming interface (API), ensuring a common software experience for users with regards to interfacing with machine vision cameras.

Machine vision platforms should offer programming software that strikes the right between ease of use for users to learn and configure, and sufficient power to implement all needed features. Configurability is important not only when the project is first installed, but also as users must maintain and even modify or upgrade the system in the future.

Advantech offers a machine vision software platform called EzBuilder which aims to live up to its name (refer to Figure 3). This software features full and partial licensing options, making it cost effective. The intuitive graphical user interface shortens the initial learning curve, helping developers to become efficient quickly. Advanced capabilities such as lighting control and connections for other software packages (such as SCADA and motion) provide the required level of flexibility. Robust security, as well as cross-platform compliance with other software packages, rounds out the feature set.

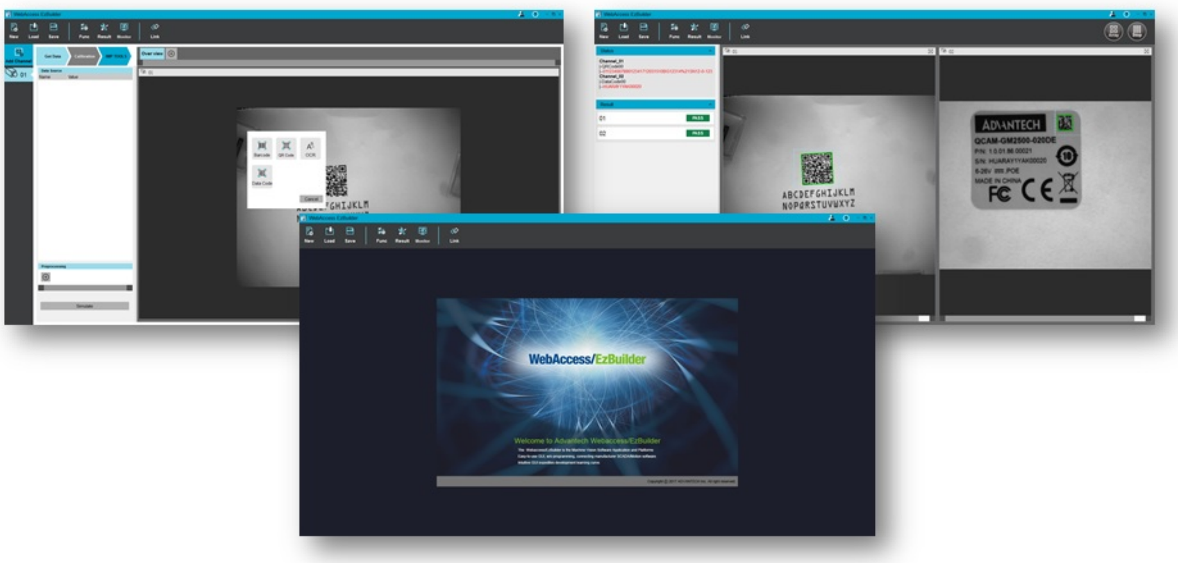

Figure 3

Once the end user has selected a solution-ready machine vision hardware and software platform meeting the requirements listed in Table 2, they are ready to start reaping the benefits.

Machine Vision Benefits

End users need to improve quality to reduce costs at all levels, and machine vision systems are well suited to achieving this goal. The performance and features of today's machine vision systems have advanced to make them a fit for more applications than ever, but perhaps the biggest improvement is due to solution-ready platforms which are easier than ever to install.

While this white paper has focused heavily on industrial factory applications, the improved accessibility of machine vision systems is opening up their use in many other industries. Most autonomous vehicles use some form of machine vision, and development on "soft robots" which can work side by side with humans also relies on vision sensing.

Machine vision is even poised to transform the basic human endeavor of agriculture. *Forbes.com* reports how mobile field robots may visually inspect the progress of crops, eventually even performing physical manipulation tasks like pruning. Fleets of vision-equipped harvesting equipment are not far away.

Contemporary machine vision hardware and software can rapidly be deployed, leveraging commercial technologies such as Ethernet. Powerful options mean most any need can be met, while simplified configuration options greatly improve the likelihood of a successful result.

The very same features making a modern machine vision system functionally effective also make it more cost-effective initially, and later in the life cycle when modifications and maintenance are required. Looking to the future, the best platforms offer useful scalability and flexible growth options.

Now we'll look at how scalable and solution-ready machine vision platforms perform in real-world applications.

Food & Beverage Bottling System

Bottling lines are excellent candidates for the application of vision systems. Due to their high operating speeds, it is impossible for humans to evaluate the product characteristics in any useful way during operation. In most cases, random manual sampling is not satisfactory, and 100% inspection is therefore required. A properly applied vision system can analyze many conditions of the entire product throughput.

Some common defect inspections include:

- Product over/under fill level
- Cap mis-installed
- Barcode proper/valid
- Optical character recognition (OCR) to determine if date/lot codes are proper
- Optical character verification (OCV) to determine the quality of printed text
- Label presence and orientation

Vision system I/O can be implemented such that non-compliant product is directed to a holding area to be reworked as necessary. The end result is far superior product quality, maximum uptime for a high speed process, and minimized operator involvement.

Manufacturing/Packaging Lines

Manufacturing and packaging lines often provide many opportunities over their entire length for implementing vision inspection systems (Figure 4). They can inspect all sorts of assembly steps to ensure labelling and packaging is properly applied. Inspecting 100% of production provides the highest level of quality assurance.

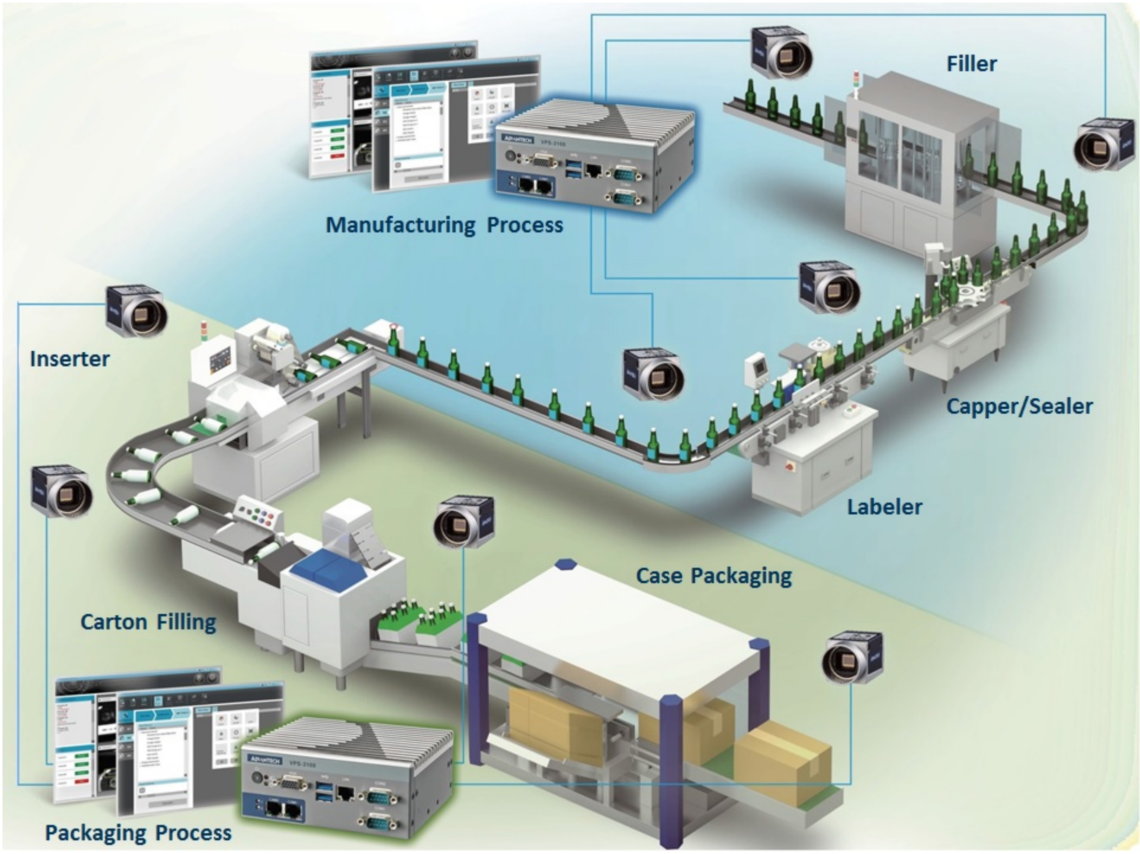

Figure 4

It is helpful to choose a flexible vision platform featuring scalability and adaptability to many different conditions, so a consistent system can be implemented throughout the facility. Using a common platform makes installation and future support easier and more economical.

Parts produced with automated manufacturing and production lines often require inspection to ensure the assembly is complete and dimensionally correct. After manufacturing, the part may be labelled and assembled or inserted with other components into a final assembly. The assembly is typically packaged into individual cartons and then cases for shipment to retail outlets.

At every step along the way, vision systems can be implemented to efficiently inspect the parts and packaging. Defects can be flagged immediately, with non-compliant products diverted. Operators can be notified and prompted to correct the production conditions before anymore faulty units are produced.

Vision systems are tireless watchers, ensuring production is correct all the time, while saving end users significant money.

Conclusion and Outlook

Machine vision is by no means a new technology, but extensive hardware and software improvements over recent years have greatly increased the usability of this powerful sensing method. Properly implemented, machine vision can operate at exceptionally high speeds to inspect production at extremely high levels of detail, offering end users a way to achieve the highest possible quality. And along with this increasing power, many recent enhancements have been aimed at making vision systems much more accessible for end users.

Scalable and modular hardware components based on dominant mass market technologies and optimized protocols enable the underlying hardware to have more than enough capabilities. Software has been improved not just by adding more features and computational capabilities, but by applying a focus on flexibility and ease of use.

Consequently, machine vision systems are moving from a specialty niche sensing technology to a common automation application. Users are now positioned to self-perform this type of work if they choose, and can realize savings over the life of the equipment.

Taken together, the latest scalable machine vision hardware and software platforms are ideally positioned to help customers solve their automation challenges.

References:

Reference 1, The Vision for Robotic Vision; Jean Thilmany; AutomationWorld.com: https://www.automationworld.com/article/technologies/robotics/vision-robotic-vision

Reference 2, How to develop reliable vision applications; Robert Tait (Optical Metrology Solutions); ControlDesign.com: http://www.controldesign.com/articles/2017/how-to-develop-reliable-vision-applications/

Reference 3, How Sensors, Robotics And Artificial Intelligence Will Transform Agriculture; Jennifer Kite-Powell; Forbes.com: https://www.forbes.com/sites/jenniferhicks/2017/03/19/how-sensors-robotics-and-artificial-intelligence-will-transform-agriculture/#3e8cce89384b