WHITE PAPER

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Laser Scanning or Digital Imaging: Which Bar Code Scanning Technology Is Right for Your Application?

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Deciding which bar code scanning technology — laser scanning or digital imaging — is right for your application can be a difficult task. The purpose of this paper is to help in your decision-making process by providing technology overviews, advantages and application uses for each of these options.

Introduction

Over the past few decades, bar code scanning has become the data capture technology of choice, enhancing processes in virtually every industry and market. Low-cost scanning solutions improve performance and reliability in a wide range of enterprise activities, and reap tremendous business benefits, including increased worker productivity, improved task efficiency, and reduced operational costs.

As scanning technology evolves and new bar code symbologies appear, industries have more choices in data capture solutions. This paper discusses two competing, and sometimes complementary, data capture devices: the laser scanner and the digital imager. We will provide an overview of the technology behind each device, list advantages for each, and discuss markets and applications in which they are used.

Bar Codes and Symbologies

First, we need to understand the target of these data capture devices: the bar code. A bar code is a printed symbol placed on a package or an item of merchandise, consisting of vertical bars and spaces that represent information about that package or item. Bar code scanners or imagers scan, or read, the bar code and capture its encoded data. This data is then displayed for the operator on a connected device, such as a mobile computer or cash register, and/or sent to a centralized database for information storage.

The applications for bar codes are vast. They are used, for example, on retail sales items, ID cards, and books. They are also used to manage work in process, for package identification in delivery applications, and automated identification applications.

A symbology is a type, or "language," of bar code. Each symbology has its own unique method of using bars and spaces to represent numeric or alphabetic digits. Laser scanners and digital imagers are programmed to decode, or understand, the specific symbologies used in their applications.

One popular example of a symbology is UPC/EAN, the bar codes used on grocery items throughout the world. Another familiar symbology is ISBN, commonplace on the backs of books. And as auto-ID and security applications become more essential in many markets, the use of 2D symbologies is on the rise. The PDF417 symbology is frequently used on U.S. drivers' licenses, postal package identification, and airline boarding passes.

Laser Scanning Technology

How do laser scanners actually "read" a bar code? These scanners employ two optical systems to help with the task.

The scanning optics system generates a laser beam and uses a lens to focus the beam. An oscillating scan mirror moves the beam back and forth rapidly across the target bar code to create a laser line which illuminates the bar code.

The collection optics system then retrieves the laser light reflected off the bar code and concentrates that light onto a photo-detector. The collection optics also enable the scanner to reject external light that can interfere with the laser light.

Next, a photodetector transforms the reflected laser light into an electrical analog signal and converts the analog signal to digital data. The scanner's decoder processes the digital data and applies a symbology algorithm to interpret the data. It then verifies the information via a check digit, typically the last digit of a bar code that tells the scanner whether it scanned the data correctly, and sends the data to the connected host.

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Laser scanners offer a number of advantages for a multitude of applications:

- Laser scanners can effectively read bar codes even when the scanner or the bar code is in motion, enabling them to achieve excellent scanning productivity. For this reason, laser scanning is the preferred technology in high-throughput areas that require motion insensitivity, such as supermarkets, where users can rapidly swipe item after item over a fixed scanner. This motion tolerance also pays off in hand-held scanning, where the user can quickly and effortlessly move from one bar code to the next. In both situations, the laser scanner allows operators to achieve high productivity.

- Because laser scanners have been around for awhile, the technology has been refined to the point where many of these scanners are less expensive than comparable imagers. The combination of low price and high productivity often makes laser scanning the better option in applications that don't require reading 2-dimensional bar codes. Because laser scanners can, however, read PDF417, a 2D-like symbology, they can also be a cost-effective option in PDF417 applications.

- Laser scanners can project a beam of light a long distance without diverging, or spreading out, as light from other sources do, enabling them to decode high density bar codes over wide ranges. This proves advantageous in applications that require scanning range flexibility, such as forklift operations where packages are often located on high shelves or hard-to-reach areas. In these cases, laser scanners can achieve 50% more range than more expensive area imagers.

- Because the laser is emitted from the line of sight of the scanner's sensor, accurate scanning is easy. The laser line represents exactly what the scanner's sensor sees, so the operator can intuitively aim the scanner properly to achieve quick decodes.

Digital Imaging Technology

Area Imagers

Digital area imagers use a different approach to decoding bar codes, but with the same end result in mind – to quickly and efficiently read the bar code.

The area imager projects LED light that illuminates the target bar code. Like a digital camera taking a picture, a lens projects the image of the bar code (and the area surrounding the bar code) onto a 2D array, and the light is converted to an electrical signal to construct the digital image. Decoder software in the imager locates the bar code within the image, and processes its data using advanced decoding algorithms. Then, like the laser scanner, the imager verifies the bar code data via its check digit and forwards the information to the connected host.

Digital area imagers present many benefits when used in data capture situations:

- In addition to 1D bar codes, area imagers can read 2D bar codes, which can accommodate significantly more data. This is beneficial in situations that require symbols to encode more information, such as transportation and logistics, and tracking applications.

- Area imagers enable omni-directional reading of bar codes, eliminating the need to re-orient labels to accommodate the scanning device.

- In addition to bar code decoding, some high-performance area imagers can capture and transfer images, enabling signature capture and other imaging applications like scanning documents. This eliminates the need for additional equipment, such as flatbed scanners, saving counter space and reducing capital and maintenance expenses. This is also useful for proof of delivery, and in field service and shipping and receiving applications for recording images of damaged cartons for proof-of-condition claims.

- Area imagers can also read Direct Part Marking (DPM), a method of permanently marking a product or component so it can be tracked throughout its life. The growing popularity of DPM has enabled serialization for unique parts to ensure product quality, and improved tracking efficiency in areas such as the pharmaceutical market to help achieve compliance with traceability regulations.

Linear Imagers

Linear imagers capture bar code data in a similar way as area imagers. Linear imagers project LED light onto a bar code, and a lens focuses the bar code image onto a CCD or CMOS sensor. A decoding algorithm analyzes the peaks and valleys of the signal and collects the bar code's data.

However, unlike area imagers, linear imagers use their sensors to capture only a single row of pixels within the image. This allows linear imagers to decode a 1D bar code, but not entire images or 2D bar codes as an area imager can. And because economical laser scanners facilitate intuitive aiming, have better motion tolerance, and are typically as reliable and rugged, they are a better choice than linear imagers for almost all 1D scanning applications.

Common Misconceptions Regarding Bar Code Decoding Technologies

Misconceptions often arise when attempting to select the best technology to simplify and increase efficiency in business applications and lower operational overhead. We'll address a few of these misunderstandings now.

Misconception #1:
Digital Imaging and Laser Scanning - One Technology is More Reliable Than the Other
When it comes to data capture technology, manufacturers of digital imagers or laser scanners typically promote their technology as being more reliable. Rather than generalize the superior reliability of one, customers must carefully analyze their individual data capture situation and then determine which method best suits their needs.

Today's high-performance laser scanners use frictionless elements that enable them to ship with a lifetime warranty because of their dependability. Digital imagers, on the other hand, also boast outstanding reliability based on their solid-state construction due to a lack of moving parts. In retail establishments, you'll often see digital imagers or laser scanners that are 10 to 15 years old operating as efficiently as ever.

So when choosing a data capture technology, be sure to apply thoughtful analysis to both the present and future needs of your enterprise, and consult the experts. This planning will pay off in application efficiency and worker productivity.

Misconception #2:
Linear Devices Support Imaging
While linear devices such as CCDs (Charged Coupled Devices) are often called "linear imagers", this misnomer fosters the mistaken idea that such devices are capable of imaging.

Linear devices use CCD or CMOS sensors to process bar code information in the same manner as area imagers. However, linear imagers use the sensors to capture a thin slice of an image (i.e., a single row of pixels), while area imagers use sensors with pixels arranged in a 2-dimensional grid (multiple rows). While this allows linear imagers to decode a 1D bar code, it does not result in a useful image for anything else.

Misconception #3:
MEMS Scanners Outperform Other Laser Scanners
Micro-electromechanical system (MEMS) based scanners are often incorrectly understood to yield performance superior to other laser scanners, based on the replacement of a single design element, the scanning mechanism. This new element enabled a frictionless scanning system. And although we know frictionless means more reliable, there had already been other types of frictionless scanners on the market for years.

However, it is also important to understand that in a complex laser scanner system, there are several things that affect performance. Merely replacing the scanning mechanism to increase scan speed will not provide the superior scanning ability many users expect. In reality, increasing the scan speed reduces signal quality, which often results in decreased working range and poor performance in decoding degraded bar codes, offsetting the benefit of the increased speed. Sensitivity to bright ambient light conditions further degrades signal quality for MEMS scanners.

To balance out these negative consequences and achieve its desired working range, a MEMS scan engine must increase the size of its optics, resulting in a much larger engine. Engine size plays a key role in scanning device ergonomics, where a smaller engine efficiently allows an optimized housing design. MEMS engines fall short in this area.

A well-designed, high-performance scanner, such as those based on Symbol's LP engines, uses the appropriate technology and thoughtfully integrates system components in a way that maximizes scanning range and performance on both high quality and damaged bar codes.

Data Capture Markets

Almost every market can benefit from the use of data capture technology. Following are just a few of these target markets and applications, some in which laser scanners prove advantageous, others more suited for digital imagers, and still others that can profit by using either or both.

Retail

Digital area imagers use a different approach to decoding bar codes, but with the same end result in mind – to quickly and efficiently read the bar code.

The retail industry was an early adopter of data capture technology throughout its multitude of applications. Because the amount and variety of retail merchandise is virtually limitless, automating processes is a must. Bar code technologies have helped accomplish this, from simplifying back-room inventory management to fostering speedy and more efficient checkout lanes.

Inventory Management

From the receiving dock to the store shelf, bar code scanning has streamlined inventory management processes. As shipments come in, warehouse workers scan bar code labels on items, cartons, or pallets. The scanned information is verified against purchase orders and sent to the inventory database for update. This ensures inventory is accurately tracked, reducing overstocks and shrinkage. Workers can capture pictures of damaged packages for proof of sub-standard condition from the manufacturer. Eliminating paper-based processes also diminishes the human error factor.

> ***Technology of Choice:***
> *Area imagers for their flexibility in decoding all kinds of 1D and 2D bar codes, and their ability to capture images. Laser scanners if you need to decode at long distances or read poor quality 1D bar codes.*

In the back room, retailers scan inventory to obtain a quick status of the quantity sold and on hand, so shelves can be restocked in a timely fashion. This significantly reduces the labor costs and errors associated with performing physical inventory, and of course yields greater customer satisfaction.

> ***Technology of Choice:***
> *Laser scanners for their low cost and high performance in decoding UPC/EAN and other 1D bar codes used in retail. Area imagers if your situation requires capturing images for proof of condition, such as in delivery applications.*

Point of Sale (POS)

At the point of sale, checkout personnel use scanners to accomplish transactions accurately and efficiently with little training. Omnidirectional laser scanners or digital imagers quickly scan bar coded items of all sizes and shapes, and cashiers can use cordless hand-held scanning devices to scan heavy or bulky items right in the cart. Area imagers can take pictures of customers for ID membership cards. These factors increase worker productivity and enhance the customer experience as checkout lines move swiftly and smoothly.

> ***Technology of Choice:***
> *Laser scanners for their motion tolerance in checkout; area imagers if the application requires image capture or decoding 2D bar codes.*

Self Service Shopping Assistance

In many progressive retail establishments, customers use portable shopping systems to scan products as they shop, ensuring they receive accurate pricing information before they pay, and speeding their checkout. Scanning kiosks provide item information, such as pricing, with a simple swipe of a bar code. These conveniences lead to a more pleasant shopping experience and promote valued customer loyalty, ultimately improving the bottom line.

> ***Technology of Choice:***
> *Laser scanners, which are the primary technology used in portable shopping and price checker kiosks.*

Warehouse Management

Warehouse Management Systems (WMS) encompass all management and tracking tasks performed within a warehouse or distribution center, including item and inventory receipt, inspection, put-away, picking and shipping.

Advanced data capture technologies have gone far in optimizing warehouse operations. Bar code scanning monitors product flow by collecting bar code data and transmitting the information to a central database, which in turn provides visibility into the status of warehouse material. In general, WMS enables more efficient movement and storage of product inventory and increases worker productivity.

At the receiving dock, employees unload packages and cartons and quickly scan their bar code labels to update package status. The item is then delivered to a staging area or directly to an outbound dock, where it is scanned again as it is loaded. This process enables real-time package tracking, allows delayed or missing items to be located immediately, and lets dispatchers predict when outbound trailer loading will complete.

In the finished-goods warehouse, scanners efficiently capture warehouse inventory information, streamlining data entry and reducing picking and packing time.

Technology of Choice:
WMS can benefit from employing a combination of laser scanners and area imagers. Laser scanners are ideal on the warehouse floor, where motion sensitivity and long range scanning are issues as workers perform duties from forklifts. As traceability becomes more important in tracking packages and merchandise from cradle to grave, area imagers are necessary in decoding DPM or the 2D symbol that contains an item's required historical data.

Healthcare

The healthcare industry encompasses all aspects of patient care, hospital and office management, pharmacy, and medical equipment administration. Bar code capture has become an essential technology component in ensuring patient safety and improving the quality of care.

Bedside Applications

Using bar code technology, doctors and nurses can scan patients' wristbands to access information quickly, right at the point of care. This provides immediate visibility into test results, blood type, and other vital health data, so medical personnel can make informed decisions at bedside, reducing treatment and medication errors based on faulty information. With this streamlined process in place, professionals can ultimately spend less time on paperwork and more quality time with their patients, humanizing the hospital stay experience.

Technology of Choice:
Area imagers for their ability to read 2D bar codes which encode more information such as patient data, and also for their omnidirectional reading, which enables caregivers to scan patient's wristbands without disturbing them.

Equipment Inventory

Hospital and doctor's office employees can scan medical tools and equipment as they are used, immediately updating inventory and ensuring critical items are replaced as necessary to guarantee they are always on hand for urgent situations. This also accounts for tools after a procedure and prevents loss of expensive equipment.

Technology of Choice:
Laser scanners are a cost-effective solution if equipment is labeled with 1D codes. For applications with stringent traceability requirements, area imagers are the solution for DPM-marked items.

Blood and Specimen Collection
Bar code solutions can help keep track of blood samples and supplies, from when it is drawn, through storage, to when it is infused. Because bar codes provide detailed information on blood units, such as donor and blood data, donation and expiration dates, a simple scan fosters accurate handling of today's blood supplies. Data capture technology also facilitates blood supply inventory, tracking quantities of various blood types on hand and matching donations to patients.

In specimen collection, bar code technologies enable precise sampling, labeling and analysis of biological specimens, ensuring the correct sample is placed in the appropriate container. This reduces the risk associated with human error, and ultimately results in faster and more accurate diagnosis, essential for timely treatment and medication administration.

Technology of Choice:
As traceability of human specimens and the blood supply becomes vital in ensuring patient safety, area imagers are required to decode the 2D or DPM symbols that encode critical tracking information.

Pharmacy Applications
Pharmacists can scan drug containers to ensure the right medication is going to the right customer, and capture a picture of the prescription to store with the patient's electronic file, as well as the doctor's member ID card for record keeping. DPM symbols on drug packaging allow pharmaceuticals to be traced throughout their life cycle, ensuring product quality and making certain items end up at the appropriate destination.

Technology of Choice:
Area imagers for their ability to combine bar code decoding, image capture, and signature capture in a single device, saving counter space, eliminating paper storage, and promoting accurate prescription processing.

Manufacturing

The manufacturing market entails all the activities required to construct a product, including assembly, work in process, and error proofing of items ranging from tiny circuit boards to jumbo jets.

Part Serialization
As serialization of unique parts becomes more popular as a method of tracking items from cradle to grave, manufacturers are turning more and more toward Direct Part Marking (DPM). This enables product components, from small PC boards used in computers, to large automotive parts, to carry valuable data that cannot wear off over time. An assembly line employee can scan this DPM symbol to determine, for instance, when a part was created, to ensure only quality components are used in building the end product.

As an example, the United States Department of Defense requires all its suppliers to serialize products valued over $5,000 with a unique ID, so these items can be tracked throughout their life cycle. This ensures parts are delivered to the correct destination, and are properly disposed of at the end of their usable life, which in some cases can be vital to national security.

Intelligent Parts for Error Proofing
Parts manufacturers label component packaging with symbols that encode information such as to which plant the part is to be delivered, according to customers' instruction. Workers at the destination plant scan the packages as they arrive and deliver them to the correct assembly line. And assemblers scan each part to verify they are using the correct

components in assembling the overall product. Serializing each component with DPM eliminates the human error factor, because with a quick decode workers know not only what product the part belongs to, but specifically where within the product (for example, a rubber sealing strip for a left rear car door).

Technology of Choice:
Area imagers for all the various DPM manufacturing applications.

Light Assembly
Component manufacturers label parts with tiny 1D bar codes. Workers scan each serialized component when assembling the overall product for parts tracing, ensuring a customer order, such as a computer, includes all requested features.

Technology of Choice:
Laser scanners for their ability to read small 1D bar codes, and for their motion tolerance for rapid picking and scanning of parts.

Auto ID and PDF417 Applications

The manufacturing market entails all the activities required to construct a product, including assembly, work in process, and error proofing of items ranging from tiny circuit boards to jumbo jets.

Unknown Sender Law
With a new security law in the works in the U.S., postal patrons will no longer be able to simply drop off a package for mailing. Post offices now require customers to present their drivers' licenses, which are imprinted with a PDF417 bar code, when mailing an item. Postal workers scan these bar codes to obtain and store all necessary information about the sender, linking the sender with the package. This, in turn, discourages exploitation of the mail system for illegal or terrorist activity.

Credit Applications
Today, many U.S. retailers are implementing systems that automatically populate customers' credit applications by scanning the PDF417 bar code on their driver's licenses. While this has initiated a shift in this market from laser scanners to imagers, there are new retail laser scanners on the horizon that will read these symbols as efficiently as area imagers, allowing support for this new application without sacrificing productivity on 1D bar codes

Age Verification
In convenience stores, employees can scan the PDF417 bar code on the U.S. driver's license of a customer purchasing alcohol or cigarettes to verify that the customer is of legal age for the transaction. At the end of the day, the store manager can compare the amount of alcohol and cigarettes sold to the number of licenses scanned to ensure that POS personnel are checking for proof of age at a reasonable rate.

Technology of Choice:
Because both laser scanners and area imagers can decode PDF417 symbols, either technology is appropriate for these auto-ID applications. Buyers should take into account issues such as pricing and whether they need the device to perform other tasks to help them make an informed decision.

Conclusion

Motorola delivers both laser scanning and area imaging technologies in rugged, reliable products designed to optimize performance and productivity in their target applications. When implementing a data capture system, technology customers must weigh the options carefully and give thoughtful consideration with respect to the needs of the application. As illustrated in this paper, both laser scanning and area imaging are powerful technologies that afford numerous benefits for their appropriate markets.

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