

xPick — vision picking for logistics

Streamline picking processes and reduce error rates.



Abstract

In today's fast-paced industries, maximizing time efficiency and minimizing errors are crucial for competitive edge. This whitepaper delves into the innovative pick-by-vision system, xPick, and its synergy with smart glasses, or head-mounted displays, enhancing productivity and reducing errors in picking operations. It demonstrates how the integration of smart glasses with xPick facilitates a hands-free work environment by projecting necessary information directly into the user's field of vision. Furthermore, it provides insights into the requirements, implementation phases of xPick, its benefits to workers, and compliance with data security and industrial safety standards.

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Introduction

Pick-by-vision represents a cutting-edge and highly promising approach in contemporary manual or semi-automated warehouse management strategies. This method employs smart glasses, also known as head-mounted displays, to present context-sensitive information directly within the warehouse worker's field of vision.¹ This is also called augmented reality-supported picking or assisted reality-supported picking.² A more than 25% productivity increase can be achieved,³ mainly due to the faster turnaround time, increased picking quality, and strict litigation.

From an IT perspective, pick-by-vision is a part of wearable computing. Wearables, or computer technology, are worn on the body or head and support activities through additional information, evaluations, and instructions.⁴

Smart glasses, also known as head-mounted displays (HMDs), received their US patent registration in 1974. An HMD consists of a head-mounted device, often resembling a helmet with a visor, equipped with a projection mechanism and a reflective surface. This design generates a specific image directly within the wearer's field of vision.⁵ Today's HMDs are based on this principle, and many different systems from several vendors are available on the market. The most popular brands include Google, Vuzix, RealWear, Dynabook, Zebra and Microsoft.

In the industrial realm, the adoption of wearable computing technologies is on the rise. These technologies find application across the entire product lifecycle. This includes the initial stages of planning and design, through to intralogistics and production, and extends to encompass supporting processes. Furthermore, the after-sales phase — encompassing maintenance, inspection, and service support activities — also sees significant advantages from the use of wearables. A key benefit is the ability to keep both hands free for physical tasks, while smart glasses and their associated solutions are becoming increasingly efficient.²

In logistics, wearable computing-based pick-by-vision solutions have significant potential to enable two-handed, value-added work. In addition to traditional order picking, other activities such as stock-keeping, indoor navigation, and stock-taking can be supported. Wearable computing solutions will also find their way into other logistics systems, such as shipping and transportation.

¹ Schwerdtfeger, B.; Klinker, G.: IEEE International Symposium on Mixed and Augmented Reality 2008, Supporting Order Picking with Augmented Reality, Cambridge, UK

² Günthner, W.; Reif, R.; Blomeyer, N.; Schedlbauer, M.: Pick-by-Vision: Augmented Reality unterstützte Kommissionierung, Garching: Lehrstuhl fml 2009.

³ http://www.dhl.com/content/dam/downloads/gO/press/publication/dhl_glass_infografik_new.pdf

⁴ <http://wirtschaftslexikon.gabler.de/Definition/wearable.html>

⁵ <http://www.google.com/patents/US3923370>

Pick-by-vision in the context of material management and logistics

Increased demands on logistics have led to more stringent logistics requirements and systems. For example, more customized products or the need for fast and adequate supply, reduced inventories and lower costs.

Picking is the core element of in-house logistics, as it influences qualitative aspects and the monetary and time factors of the entire logistics process.⁶ The order picking process describes the process of putting goods together according to given orders from a complete assortment.⁷ A distinction is made between a one-step process (picking) as a sequential processing of orders and a multi-level process (multi-order picking) in which orders are subdivided and processed jointly for efficiency reasons.

The picking process itself is divided into **5 phases**:

- 1** The base time as preparation for the actual order picking
- 2** The travel time, i.e., the time required for the passage from shelf to shelf
- 3** The gripping time, which describes the actual picking with counting, etc., until it is deposited
- 4** The dead time, for example, the identification of the storage bin, control of the removed goods, or the response time in case of errors⁸
- 5** The distribution time, which describes other unproductive processes (conversations, personal needs)

⁶ Günthner, W.; Reif, R.; Blomeyer, N.; Schedlbauer, M.: Pick-by-Vision: Augmented Reality unterstützte Kommissionierung, Garching: Lehrstuhl fml 2009.

⁷ <http://wirtschaftslexikon.gabler.de/Definition/kommissionierung.html>

⁸ <https://logistikknowhow.com/kommissionierzeiten-totzeit/>

Various systems support and optimize the picking process in its different phases. Depending on the system, the individual phases are influenced positively or negatively. The systems include:



Pick-by-paper: Paper-based order picking is very rare in its original form today and is mainly used as support for digital picking methods.⁹ Before today, paper-based systems were used.



Pick-by-scan/pick-by-barcode:

A digital method in which mobile data acquisition devices (MDE) display order information and confirm the removal or storage by barcode scanning.



Pick-by-light/put-to-light: Storage compartments and systems are equipped with signal lamps or alphanumeric display systems. During picking, the signal lamp lights up on the storage compartment or the storage compartment of the current pick position, and the number to be withdrawn appears on the display.¹⁰



Pick-by-voice: Core elements of the system are software for translating the pick data into human speech and a voice recognition system for digitizing human voice commands. Job information is sent as voice instructions to the picker, who acknowledges execution of the paging and filing process by sparing error.



Pick-by-RFID: Like the pick-by-scan picking system, no barcodes are used to identify the goods to be stored but RFID readers. The goods are provided with so-called RFID tags that allow clear identification.

Pick-by-vision also supports the order-picking process whereby order picker information is displayed sequentially in the field of view via HMD. Various sensors are used to confirm and document the retrieval and storage process.

⁹ Günthner, W.; Reif, R.; Blomeyer, N.; Schedlbauer, M.: Pick-by-Vision: Augmented Reality unterstützte Kommissionierung, Garching: Lehrstuhl fml 2009.

¹⁰ http://www.fml.mw.tum.de/fml/index.php?Set_ID=945&letter=P&title=Pick-by-Light



Summary:

Pick-by-vision is a group of digital order picking systems that support the order picking process. This is done by providing contextual information in the picker's field of view using smart glasses.

Definition of pick by vision

Pick-by-vision uses smart glasses (HMDs) to show the picker all the data needed to perform his job directly in the field of view. Not only can static data such as text or image information be visualized, but also the use of a tracking system to determine the position and viewing direction as well as dynamic data positioned in space. These spatial 3D geometries point through the warehouse or visually highlight the picking or storage location.¹¹

For technical reasons, solutions that are in use do not require the visualization of dynamic, spatially positioned data (augmented reality/mixed reality) but are focused on a pick-by-vision solution with static information (assisted reality). Nonetheless, highly dynamic visualizations can support the order picker in his work and thus exploit future potential.

The functions of a pick-by-vision solution are decisively determined by the process to be supported. In principle, however, three general functions can be distinguished across all systems:

- ✓ Information functions, usually as an audio-visual information output to the picker
- ✓ Interaction function for identifying articles, confirming tasks, or documenting events
- ✓ Functions for technical or operational logistical support

¹¹Günthner, W.; Reif, R.; Blomeyer, N.; Schedlbauer, M.: Pick-by-Vision: Augmented Reality unterstützte Kommissionierung, Garching: Lehrstuhl fml 2009.

Pick-by-vision system description

The essential elements of the complete pick-by-vision system include the software solution, the digital information, and the hardware.

Software

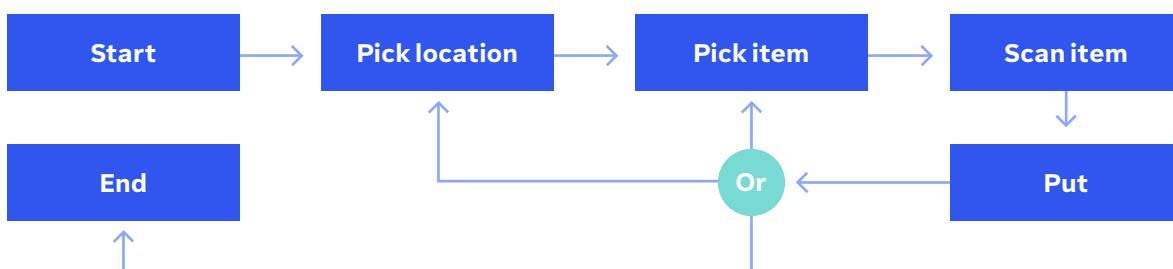
The software solution is adaptable to individual operational, technical, and user requirements to maximize the solution's potential. Flexibility in this context refers to flow control, display information delivery, the ability of the user to interact with the solution, and the ability to integrate with an existing IT infrastructure.



Process control/workflow: Due to different corporate or customer requirements for the logistics process, flexible and variable workflows are becoming more and more important. The workflow determines which work steps the picker must perform, how, and in what order. The workflow also defines what information is presented to the user, how it is presented, and how the user interacts with the system.

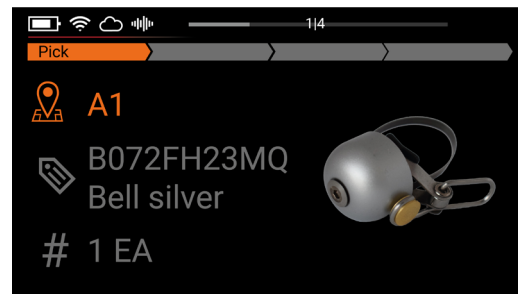
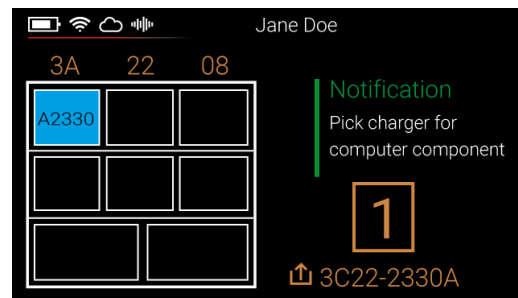
Information provision uses not only classic text information but also images or animated

graphics. Combinations of audio-visual information are also common. To confirm or input information like quantities or part numbers pick-by-vision solutions offer the classic operation via mechanical buttons or touch pads, barcode or QR code scanning, and voice or gesture control. The confirmation of an executed work step, or the data entry, can thus be realized hands-free.



Providing information on the display/

user interface: As with the workflow, the user interface requires a certain amount of flexibility to ensure optimized process support and provide contextual information in the field of view of the order picker. The design process can be customized to suit the design. Various graphic or text data can be integrated. It should be noted that display sizes vary per hardware model. The amount of information, content, and process must be adjusted to the display used. Suppose the camera of the smart glasses is used for barcode scanning. In that case, the live camera image is integrated into the user interface, which is similar to a viewfinder of a camera and positions the camera above the barcode.



Interaction: Pick-by-vision solutions offer different possibilities for interaction. The familiar barcode scan is used here to confirm the removal and storage. An integrated camera or external barcode scanner can identify the barcode. Another standard method is the interaction via voice commands. Simple voice commands such as Next, Return, Ok, etc. are used for control. Multilingualism and learning systems (for dialects or when using the system by different people) are also available. Multilingual and learning systems are also available. Manual input via a mechanical keyboard/touchpad on the HMD is used as a backup or at system startup. Depending on the process, other wearables, features, or external control systems may be used.

Integration: Today's systems offer various integration options that not only affect the connection to backend systems (interfaces), but also the integration of additional functions and hardware modules. One of the classic hardware modules is the external barcode scanner, which eliminates the advantage of hands-free operation, but may be necessary from an ergonomic point of view. Additional functions include OCR character recognition, object recognition or location.

Information

Due to the complexity involved, the information presented is often simplified to a select number of text, graphical, or pictorial representations, along with interactive elements. These are designed to provide enough information for accurate selections and are utilized based on the context. Commonly, the information provided includes:

- ✓ Order (name, ID, and quantity) of the goods to be picked in textual or pictorial form
- ✓ Storage space in textual and graphical form
- ✓ Upcoming order and textual description of its storage location¹²
- ✓ Colored markers or graphic elements to visualize status information or errors
- ✓ Supporting audio information as confirmation or error tones

Working with the system produces extensive data for control, documentation, and quality assurance and delivers comprehensive reports to the designated systems. Which includes:



**Status information
for completing/
processing the order**



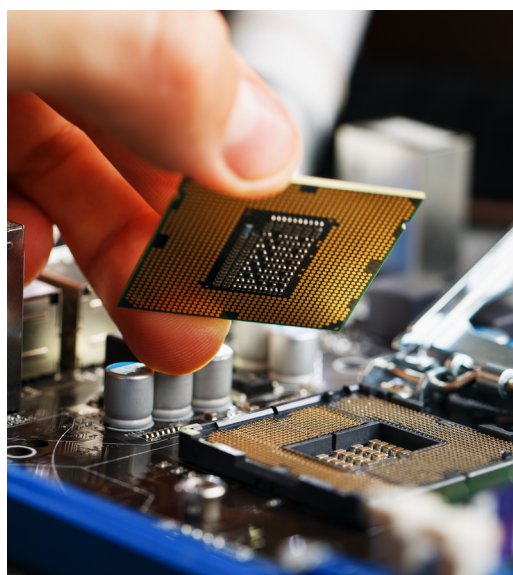
**Image information
for documentation**



**Other information
used for analysis and
technical monitoring**

Hardware

Head-mounted displays (HMDs) are generally divided into two different types: monocular and binocular systems. Monocular systems are equipped with precisely one display, which can be transparent or non-transparent and is usually positioned above the field of view. Binocular systems offer two displays placed in the user's field of view and extend this with digital information. Binocular Head-Mounted Displays (HMDs) come in both transparent and non-transparent models. However, they're not currently utilized in productive vision-picking solutions, primarily because they don't support dynamic information.



¹² Baumann, H.: ORDER PICKING SUPPORTED BY MOBILE COMPUTING, Thesis Mathematik und Informatik Universität Bremen, Januar 2013

HMD examples:

- Monocular: Glass Enterprise Edition 2, Vuzix M400, Vuzix Blade, RealWear HTM1, Toshiba dynaEdge & AR 100, Zebra HD4000
- Binocular: Epson Moverio, Microsoft HoloLens

**Monocular****Binocular**

HMDs, much like computer systems, feature a computing unit and offer various interaction methods. However, the compact design of smart glasses necessitates different construction and interaction approaches due to their size and how they are worn on the head. Traditional interaction techniques for HMDs include the use of hard buttons or touchpads, as well as a microphone and camera for input, with displays or speakers serving as output. Additionally, the system may incorporate extra sensors, such as a digital compass, acceleration sensors, and more, to enhance functionality.

In the pick-by-vision scenario the display and camera serve as primary tools. The display offers constant information within the user's line of sight, while the camera is utilized for barcode identification.

Besides integrated hardware components, the system employs process-related external sensors connected through Wi-Fi or Bluetooth to the HMD, facilitating interaction. These external sensors encompass:



Barcode handheld scanner or ring scanner



Digital measuring and weighing systems



Headset with microphone



RFID bracelet

Summary

The pick-by-vision solution comprises various technical and process-oriented components, each meticulously designed to enhance the supported picking process. This encompasses the software solution, the hardware utilized, and the information presented or generated, all working together to optimize efficiency.

Services around a pick-by-vision system

To use a pick-by-vision system and achieve the desired results, a variety of services are required.

Individual consultation for hardware and software

Consulting services, in the sense of a technology overview, primarily create transparency regarding the vast number of different usage scenarios, as well as the market for suppliers of hardware and software. The more individual a consultation is, the more it can focus on the individual application case. The more generalized the information is, the greater the insight into different use cases and approaches to adoption. This influences the organizational change that can be made through pick-by-vision projects.

Provision of demonstrators

Demonstrators help primarily in a pre-project phase to test a pick-by-vision system in its basic form or to prepare for a subsequent pilot test. The focus of a demonstrator should be interaction, haptics, ergonomics, display design, or even software development in a specific environment. In addition, demonstrators offer the opportunity to present the system to many future users, integrate them early, and support the system's acceptance.

Piloting with software adaptation

Due to the nature of a pick-by-vision system, pilot installations are in demand or offered as a service by solution providers. Use case or field of application are identified in this project phase, and the overall system should be configured for testing according to the following criteria (see chapter Software):

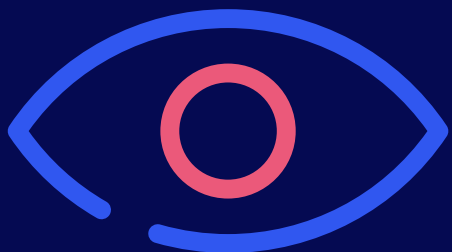
- Use of different smart glass hardware
- The way in which information is provided
- Backend integration
- Interaction
- Process structure within the software (workflow)

The pilot's aim should be to make the system operational and subject the system to extensive testing or benchmarking against the previous picking method. Solution providers often offer exceptional support within the pilot runtime to achieve these goals.

Roll-out and operational support

Typically, the deployment is the duty of the end user, who intends to implement the fully operational system across all intended application areas. This phase often presents challenges due to scaling effects, such as training all users, addressing initial inquiries, or managing the system. Solution providers assist by offering training materials or employing methods proven successful in previous projects.

In continuous operation, essential tasks like software upkeep and upgrades, hardware maintenance and replacement, troubleshooting, and even help desk support are crucial for the system's overall functionality. When support infrastructures are already in place for the user, the scope of services offered by the service provider can be tailored and divided among the stakeholders as agreed.



The human eye plays a pivotal role in information absorption, capturing 70% to 80% of the data we encounter.

Summary

Services related to a pick-by-vision system are crucial, ensuring that the system is tailored to the customer's specific use case and seamlessly integrated into productive operations, achieving the project's objectives.

Benefits

The advantage of a pick-by-vision system for order pickers lies in the continuous access to context-specific information and the ability to work with both hands.

The human eye is an extraordinarily effective tool for absorbing information, capturing between 70% and 80% of all data it encounters. Utilizing visual presentation techniques markedly enhances both performance and quality. Technologies that convey information visually have consistently demonstrated their effectiveness. Moreover, focusing attention by displaying only the necessary information in a condensed format can enhance concentration. The adoption of smart glasses enhances work efficiency by allowing hands-free operation and eliminating the need for handheld scanners and other tasks that do not add value. Additionally, it enables multitasking, which leads to improved outcomes.

The solution offers significant benefits, leading to enhanced productivity. This improvement can be quantified by critical logistical metrics such as speed (number of orders processed within a given time frame), quality (accuracy rate in order fulfillment), and flexibility (the ability to modify and adapt warehouse infrastructure and software).



Without HMDs



With HMDs

Key success factors of a pick-by-vision system

The enhancement of efficiency via vision picking primarily hinges on three pivotal factors: the deviation from traditional methods, the parallelization of tasks, and the reconfiguration of process steps, all significantly driven by automation and technological advancements. Furthermore, achieving optimal utility relies on multiple factors that come into play while implementing a solution.

¹³ Günthner, W.; Reif, R.; Blomeyer, N.; Schedlbauer, M.: Pick-by-Vision: Augmented Reality unterstützte Kommissionierung, Garching: Lehrstuhl

Situation analysis

Only some logistical applications can be made more efficient through vision picking, and added value can be increased. High potential is provided by processes that require manual work with both hands and a high variance of tasks to be worked through; thus, supporting digital information must be made available. Examples include manual commissioning of different products or sorting.

Recommendation for action: From a scientific perspective, numerous studies have explored the concept of vision picking, offering insights into its applications. Furthermore, companies, users, and experts can acquire practical knowledge on leveraging data in logistics for productive use through trade fairs and conferences.

Ergonomics

Pick-by-vision offers numerous benefits that increase the ergonomics of the workplace. A key factor is the availability of both hands to provide services (hands-free). In addition, the entire system is individually adapted to the needs of the process/user while taking occupational safety guidelines into account.¹⁴ Ergonomics is also considered in terms of wearing comfort and providing information to the hardware in the pick-by-vision system. Optimization activities on the part of smart glasses manufacturers concern the optics, weight, weight distribution, and the device's center of gravity. In addition, alternative carrying systems are offered, which include, e.g., allowing attachment to an existing vision aid or wearing the system using a headband. The ability to customize smart glasses to the individual user enhances the comfort of wearing them.¹⁵

Enhancing ergonomics minimizes the need for head movements by ensuring information is always visible in the user's field of view. It also introduces alternative interaction methods, such as voice control, enhancing user experience.

Recommendation for action: Service offerings related to the testing of solutions provide unique insights into the usability and ergonomics of vision-picking solutions. Although these solutions may not be customizable for each user, testing helps identify challenges early, allowing for their consideration in the solution's overall design.

¹⁴ Günthner, W.; Reif, R.; Blomeyer, N.; Schedlbauer, M.: Pick-by-Vision: Augmented Reality unterstützte Kommissionierung, Garching: Lehrstuhl fml 2009.

¹⁵ Günthner, W.; Reif, R.; Blomeyer, N.; Schedlbauer, M.: Pick-by-Vision: Augmented Reality unterstützte Kommissionierung, Garching: Lehrstuhl fml 2009.

Acceptance

Low data interpretation skills and insufficient understanding of pick-by-vision systems are the main obstacles to their wider acceptance among workers and employee-oriented organizations. Similarly, personal apprehensions and resistance towards changes and innovations in the workflow contribute to the rejection of these systems. Consequently, focusing on educational efforts in this domain is crucial to overcome these challenges.

Recommendation for action: Incorporating the end-user during the project phase fosters trust and acceptance for the entire system and allows order pickers to enhance system processes or interaction methods and elevate the system's overall ergonomics.

Occupational health and safety

Scientifically, the effects of a pick-by-vision system or general effects of wearing an HMD are divided into physical and psychological effects.^{16 17}

A study comparing Head-Mounted Displays (HMDs) with tablet PCs found that HMDs can lead to visual fatigue and mild head and neck discomfort. This discomfort is mainly attributed to the unnatural lack of movement required during use. However, no significant differences were observed in the application tested when it comes to objective stress indicators. Monocular displays appear less burdensome because they offer a more comfortable fit.¹⁸

From a physiological perspective, the research indicates that continuous use of Head-Mounted Displays (HMDs) does not affect visual field sensitivity, visual acuity, symptoms of simulator sickness, perceived stress, or muscle activity.¹⁹ Similarly, age and display type play only a minor role. Furthermore, the study reveals that initial headache and eye pain symptoms diminish over time.

Recommendation for action: Involve internal company groups in occupational safety and health early in the project. This allows them to explore these innovative solutions thoroughly. Pickers should be given time to familiarize themselves with and customize the system. The solution provider should provide information, such as user manuals and calibration options.

¹⁶ BAUA Bericht: Head-Mounted Displays – Bedingungen des sicheren und beanspruchungsoptimalen Einsatzes Physische Beanspruchung beim Einsatz von HMDs; Dortmund/Berlin/Dresden 2016

¹⁷ BAUA Bericht: Head-Mounted Displays – Bedingungen des sicheren und beanspruchungsoptimalen Einsatzes Psychische Beanspruchung beim Einsatz von HMDs; Dortmund/Berlin/Dresden 2016

¹⁸ BAUA Bericht: Head-Mounted Displays – Bedingungen des sicheren und beanspruchungsoptimalen Einsatzes Psychische Beanspruchung beim Einsatz von HMDs; Dortmund/Berlin/Dresden 2016

¹⁹ BAUA Bericht: Head-Mounted Displays – Bedingungen des sicheren und beanspruchungsoptimalen Einsatzes Physische Beanspruchung beim Einsatz von HMDs; Dortmund/Berlin/Dresden 2016

Data protection

Like all software systems utilized in the industry, pick-by-vision solutions offer adequate measures to guarantee data integrity, confidentiality, and availability. These measures can be customized or activated individually. Moreover, integrating certificates or similar security mechanisms with commercially available systems is straightforward.

Since smart glasses are mobile systems, functions for mobile device management also play a role here. These are usually already integrated into the actual solutions but can also be provided by third parties and operated as a software solution.

The HMD can also record sensitive data through its integrated head-mounted camera. It's crucial for both the solution provider and the customer to credibly guarantee that this information isn't exploited to harm others.

Recommendation for action: Before the project starts, inform yourself whether and which data protection mechanisms exist and whether they comply with your IT security guidelines or can be configured according to your specifications.

Conclusion and outlook

Pick-by-vision offers an innovative and efficient approach to enhancing the picking process, streamlining operations, supporting users, and boosting productivity. Ergonomically wearing the hardware on the head eliminates unnecessary, non-value-adding activities. Additionally, this system significantly improves user well-being and acceptance.

Utilized in various logistical tasks such as sorting and inventory management, pick-by-vision solutions have revolutionized order picking since their productive deployment at leading companies like DHL, Samsung, and Daimler in 2015. These projects have unveiled the technique's vast potential, prompting hardware manufacturers to tailor their solutions and services more closely to industrial applications.

Moreover, the logistics sector is now leveraging augmented reality to create stable, efficient solutions, a practice that took off in 2017 and 2018. This trend, propelled by advances in hardware technology, is poised for significant growth in the next two to four years, promising further enhancements in logistical operations.



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