Use of Augmented Reality to assist warehouses of Retail Chain

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ABSTRACT

The role of Augmented Reality in warehousing is becoming more significant day-by-day. With the ever-increasing demand of orders in shorter time frames has put enormous pressure on the warehouse managers. This paper examines the use of augmented reality in warehouses. Analyzing the use cases and applications of augmented reality in warehousing, we understand the benefits and challenges associated with it. This paper studies the key performance indices impacted by the implementation of this technology in the warehouse. The key findings with respect to the gaps identified have been put forward. This paper also acts as a theoretical guide for understanding Augmented Reality in warehouses.

Introduction

In today's aggressive business conditions, swift and seamless warehouse operations are the need of the hour. A crucial element of the supply chain, warehouses are now considered to provide a strategic edge than being seen as a traditional storage building.

Warehousing cites to the activities engaging in the storage of products on a huge scale in a precise way and accomplishing their availability whenever required. The need for a warehouse to store different types of products or goods to maintain seasonal production, seasonal demand, quick supply, continuous production, price stabilization (Bruccoleri et all 2014). In this fast-paced digital world, warehouse supervisors face extreme pressure of meeting the increasing demand in smaller timeframes. Any blunder or lag can lead to customer attrition, which can have a negative impact on the company. The total cost of warehouse operations constitutes to about 20 % of all logistics costs and more than 80% of the warehousing operations are operated manually. Hence, human availability, judgments, knowledge, skill, attitude, and productivity has a large influence on performances and costs. Warehouse operations where warehouse staff have a profound influence on the execution include order picking, warehouse planning, and inventory management. The urge for automating the warehouses originates from the fact that manual handling systems may lead to human errors which may affect the warehouse utilization.(BSS Tejesh, Neeraja 2018) A few of the disadvantages of performing operations manually in the warehouses are the high chances of human mistakes/errors, a constant rise of labor expenses, and poor item handling efficiency.

Augmented Reality has shown immense promise by enabling the warehouse workers with invaluable insights, which aid cost reduction and optimize operations. Augmented Reality enriches everything you see with supplementary relevant information. It is nothing but an augmentation of the information of virtual reality, which is superimposed to the actual environment. In this setting, information could be texts, visuals, video-recording, audio, response, prompts, and navigation information (GPS). (Holger Glockner, 2014). According to (Holger Glockner, 2014), Augmented Reality involves four primary and well-defined actions, which are then combined together to generate the output. These four tasks are: i) Screen Capture ii) Screen Identification iii) Scene Processing and iv) Scene Visualization. Foremost, the space that you want to augment needs to be captured using devices, for instance, video-cameras, smartphones, or HMD (head-mounted display) (Alkhamisi & Monowar, 2013). These devices help to capture the image, which is the field of vision of the operator. Further, the captured image needs to be scanned to identify the precise points where the virtual information has to be inserted (Alkhamisi & Monowar, 2013). These points are recognized through markers (visual tags) or through technologies that are used for tracking, for instance, GPS, sensors, infrared, or laser (Alkhamisi & Monowar, 2013). Scene-Identification classifies scenarios and is one of the main actions in reality augmentation (Alkhamisi & Monowar, 2013). As the scene grows to be known and distinguished, the required virtual information is demanded, either from open source portals or from AR solution database. Lastly, this Augmented Reality solution displays an image that includes the mix of actual-world space and the virtual-information giving the operator or the user and immersive experience (Alkhamisi & Monowar, 2013).

Augmented Reality in Warehousing

In a more recent study, on AR systems focused shipyard. This paper identified many applications, such as quality control, assistance in the manufacturing process, visualization of the location of products and tools, management of warehouses, predictive maintenance using data mining, augmented communication, visualization of installations in hidden areas and remote operation of IIoT and smart connected products and devices. (Fraga-Lamas et al. 2018)

In warehouses, workers have to navigate the warehouse using their judgment and paper pick lists, slowing the order fulfillment process. Generally, in many circumstances, an items position/location is made note of only at the entry point or the exit point, where they are scanned. This makes it difficult for the warehouse operators to know where the exact location of the item is. They spend a lot of time navigating within the warehouse to know the accurate location of the item. Furthermore, lifting large goods and simultaneously handling the paper-checklist or the clipboard can cause mishaps and can break the products/items. There are times that operators perform the given task without unclear instructions leading to similar consequences. In addition, the products are sorted and scanned manually. Even on arrival into the warehouses, the inventory is not checked upon for damages and shortages. Employees use their judgment to load trucks, resulting in an inefficient use of space (Zia Yusuf, 2020) .

AR wearables provide hands-free assistance by displaying the digital pick list in the field of vision of the picker. Further, they optimize indoor navigation by optimum route planning, which gives the most efficient path for task completion. The image-recognition operating system uses automatic QR-code scanner abilities to verify that the warehouse operator has reached the correct position, right shelf, eventually guiding them to pick the correct item. The warehouse worker scans the product, which enables real-time stock updates to Warehouse Management System. Augmented Reality solutions can identify any defects or flaws in the item.

DHL, GE Healthcare and Intel are few of the industry examples of Augmented Reality in warehousing. DHL had partnered with Ricoh to test their Augmented Reality solutions in their warehouse in Netherlands where they witnessed an increase of 25% in their picking efficiency (Taliaferro, 2016). This method of order picking using AR solutions kept the hands of the warehouse operators free, there was no need to use external scanners and paper checklist were not needed anymore (Taliaferro, 2016). In addition, the time invested in training new employees reduced significantly and the language barriers among the warehouse workers was also bridged (Taliaferro, 2016). In comparison to the standard process, the GE Healthcare warehouse workers completed the order picking process 46% faster on acquiring latest order picking list using Augmented Reality solutions (Martin, 2017). GE has found that workers complete tasks 15% faster using AR solution and could save millions over the next decade (Martin, 2017). Intel is using Augmented Reality and has witnessed reduction in the order-picking time to about 29% and the error-rates have fallen close to null (Joan C. Williams, 2018). Intel has observed that with the use of Augmented Reality solutions, new employees have achieved picking speed, which is 15% than the picking speed achieved by the employees who were trained using the traditional method (Joan C. Williams, 2018).

Use Cases of Augmented Reality Solutions in Warehousing

No.	Use Cases	What AR should do
1.	Receiving	• Scan the item/product information • Initiate automatic examination of the item/product received, to examine the quality and quantity • Show unloading details of the product/item. • Provide step-by-step instructions on how to unload the product/item/container as per the size, dimension, and weight.
2.	Storage	• Notify the worker regarding the new task assigned. • Show optimal location for the storage of the items. • Show photos and information regarding the product that has to be stored. • Provide the most optimum navigation route for storage. • Update in the WMS about the item stored.
3.	Picking	• Notify the worker regarding the new task assigned. • Show the order picking list in his field of vision • Show photos and information regarding the product that has to be picked • Show where the product-to-be-picked is located • Provide the most optimum navigation route to reach the location with help of marking system • Provide prompts when the worker has reached the location or if he has taken the wrong route • Spot the product with the help of image recognition • Barcodes of the product has to be scanned • Display information about object • Provide an indication or a prompt, on where the product has to be kept in the cart • Provide details to avoid overcrowding in the warehouse • Conduct automated examination of picking
4.	Shipping and Handling	• Display the cardboard type to be used. • Explain how to put/arrange the product in the package • Display how the items have to be placed in the pallet according to the order type, delicateness, and target location • Inspect the items that have to be loaded • Display loading optimization • Show stacking / packing information
5.	Safety Management	• Identify the glitches • Carry out an automatic review of the item • Provide caution related to item and the safety • Provide caution related to process and the safety
6.	Inventory	• Real-time stock updates
7.	In house Navigation	• Provide directions to navigate within the warehouse • Provide dynamic traffic data with help of maps

8.	Training and Communication	• Provide guidance and give direction for the next action • Provide assistance in training by means of directions • Support video transmission / streaming • Document process execution • Display and translate texts

Table 1: Use Cases of Augmented Reality in Warehouses (Wang et al., 2020)

Applications of Augmented Reality Solutions in Warehousing

Augmented Reality is used for the process of picking orders. Earlier this process was carried out either using the paper list or through pick-by-voice method, which resulted in inefficiencies (Merlino & Sproge, 2017). Inefficiencies in order picking has a huge influence on the customer services and the total warehouse operating cost (Mahroof, 2019). Order picking in itself constitutes to about 50-70% of the total warehousing operational costs (Khanzode & Shah, 2017). A warehouse worker has to perform many steps/tasks in order to pick an item/product successfully (Merlino & Sproge, 2017). For instance, warehouse workers has to find the right item/product, use the scanner to scan the item, and deliver them to the target destination for product-loading (Merlino & Sproge, 2017). How does AR help in this scenario? The required process details and product information are shown to the user in his field of vison through the Augmented Reality wearable devices (Merlino & Sproge, 2017). Warehouse workers are provided with Augmented Reality wearables (smart glasses) for this process of order picking (Holger Glockner, 2014). Every picking staff can view digital pick lists. The solution provides the most optimal navigation route, to efficiently locate the right item and, once the item is scanned, it is updated into the Warehouse Management System, reducing picking errors and search time (Holger Glockner, 2014). The AR wearable device then immediately directs the picker to the next item in the list.

AR solutions can help in optimizing the use of warehouse space through a digital, interactive 3D warehouse layout, which aids and decreases the amount involved in planning and redesigning the cost of warehouses (Joshi, 2019). It also helps to visualize the different projections of the warehouse that will be constructed next, before the commencement of the same. (Merlino & Sproge, 2017). Not only will it saves costs, but it also gives you a first hard experience of what you want to achieve, even before implementing it (Merlino & Sproge, 2017). Inventory management is instrumental for the design of the warehouse and its optimization (Mourtzis et al., 2019). With AR, warehouse managers and workers can manage stocks all hands-free and in a more accurate manner leading to Inventory Management (Joshi, 2019). The AR wearable devices scans the item to check whether the correct item is picked and provides a real time update to the WMS, resulting in updated inventory. The AR solution also directs workers to efficiently navigate across the warehouse to find the items by calculating the most efficient route, resulting in navigation optimization.

AR devices are used for optimized product loading. It replaces the paper load lists and load instruction sheet (Merlino & Sproge, 2017). The warehouse worker handling the loading process gets the load list and set of instructions in the display of his Augmented Reality device (Holger Glockner, 2014). With the help of Augmented Reality devices, all the necessary information and instructions is made available in the field of vison of the loader, rendering the printed load lists unnecessary (Holger Glockner, 2014). This speeds up the loading process, improves item handling, avoids improper handling, and ensures load optimization (Holger Glockner, 2014). A staff equipped with AR devices can take a swift glimpse towards the loaded pallet/ target load destination to verify whether the completion of the loading process. AR devices could also scan the load/item to identify any harm or defects.

Delivery vehicles come with already installed GPS navigation system (Merlino & Sproge, 2017). However, AR solutions provides real time analysis of the dynamic traffic and all the necessary data is displayed in the field of vision of the driver, providing dynamic traffic support (Holger Glockner, 2014). All the crucial data of the environment, transport, and the load is superimposed to obtain optimized routing, improved safety, and minimized distraction for the driver (Holger Glockner, 2014). Maintenance and Repair is also of the applications of AR solutions in warehousing. The AR solution provides gradual, one step a time directions for servicing and assembling parts; which allows the staffs hands to be free inorder to perform these tasks (Holger Glockner, 2014). The main objective behind it being to control quality and to significantly reduce training costs (Holger Glockner, 2014).

Benefits and Challenges of Augmented Reality Solutions in Warehousing

The prime goal of the Warehouse is to control the flow of products or items. The products must be managed cautiously otherwise it may affect on time, cost. (A.Ramaa 2012). The main advantage of AR is the reduction of order picking error. A decrease in the error rate reduces the amount of rework to be done, thus increasing the speed. The AR device displays a digital picklist in the field of vision of the worker and guides them to the right spot to pick the right object. Augmented Reality helps to establish an efficient and optimum navigation route to reduce the move-around-time in the warehouse. AR-enabled order picking increases the quality since it facilitates real-time object recognition and automatic double-checking. The warehouse workers do not have to remember the steps to complete the actions while order picking. If the operator is confused, his next steps is shown in his field of vision. AR devices have the provision to send picture of the damage/problem to the warehouse manager if he is not present. The AR software provides gradual, one step a time directions for servicing and assembling parts; which allows the staffs hands to be free inorder to perform these tasks, leading to less dependency and improved reliability. Implementation of AR in warehouses can be safer for human operators as AR devices gives prompts and feedback to warn the operator about an immediate danger. The use of AR solutions leads to a reduction in the cost of training and onboarding. Onboarding and training time for new workers and staff of all language has reduced considerably as Augmented Reality solutions

are easy-to-use and demand least communication. AR application helps to identify the location of the warehouse workers and evaluate their productivity. One of the tangible benefits of AR is the increased productivity because of more precise results on every task and enhanced engagement. AR allows the warehouse workers to scan the product and provide an update in the Warehouse Management System simultaneously, enabling real-time stock updates.

One of the main challenges of AR implementation in the warehouse is the battery life of the devices. The battery of AR devices drain down very quickly, which means that it is not meant to last for long hours. An alternative to this issue could be the use of extra batteries. However, to carry them around always can be difficult. Most of the AR devices are not meant for constant usage, since wearing them for a long period of time causes comfort issues. The devices are bulky and causes headache, eye tiredness, fatigue and for some operators who need to wear spectacles with the devices, this becomes a problem (Kim et al., 2019). The AR devices become slow eventually after prolonged use or complex computing as the processors overheat. External scanners and mobile cameras are speedier and efficient when it comes to scanning the QR codes. AR devices have in-built cameras and provide object recognition as well as scanning. Image-based scanning is slow and its precision is lesser than traditional barcode scanning. Hence, to speed up the scanning process, new AR smart glasses use external barcode scanner. Certain operations performed using hand held devices is faster in comparison to the head- mounted applications. Another challenge of AR in the warehouse is the software limitations. There are difficulties in software integration with back-end platforms like customer relationship management (CRM), inventory management, point of sale (POS), accounting, or enterprise resource planning (ERP) systems (Stoltz et al., 2017). New standards and interfaces are required to integrate into the existing warehouse management systems (WMS). People acceptance could also be one more issue. Warehouse workers may not be willing to wear the device with mic and camera on all the time. The cost of implementation of AR could be very high. The maintenance of these devices cost extra. According to (de Souza Cardoso et al., 2020), marker reliability could be one of the concern too. There are times the markers tags might not have distinct shape, have low resolution or bad image quality causing lag in performing tasks. Other challenges associated with the implementation of Augmented Reality in warehousing are confidentiality and security concerns, authorization of content and instruction as well as transfer of data (Masood & Egger, 2019).

KPIs impacted by the implementation of Augmented Reality Solutions in Warehousing

Receiving	• Receiving Productivity • Receiving Accuracy • Receiving Cycle Time
Put away	• Put away Productivity • Put away Space Utilization • Put away Accuracy

	• Put away Cycle Time
Storage	• Storage Costs • Storage Productivity • Space Utilization
Preparation (Pick and Pack)	• Pick and Pack Cost • Cost of Returns • Picking Productivity • Use of Packaging Materials • Equipment Utilization • Picking Accuracy • Returns Rate • Pick and Pack Cycle Time
Shipping	• Perfect Order Rate • Order Cycle Time • Perfect Order Percentage

Table 2: List of Warehouse KPIs affected by Augmented Reality

Key Findings

To gain access to large volumes of data, and combine it in a significantly, can be a challenge in itself. Warehouses need a solution that enables the data flow, which interlinks data across every application, product, and process.AR devices can use a large volume of data generated by IoT solutions to assist warehouse workers to be more efficient. An IoT-AR solution provides an optimal route path for navigation across the warehouse, which reduces the number of warehouse staff required for the order picking process and saves time. The location-tracking feature of IoT helps to identify the location of items quickly. The benefits of IoT-AR solution concerning the warehouse are increased productivity, improved wellbeing of the workers, better utilization of space and labour. While for operators, it improves workplace safety, reduces fatigue, reduces travel time and distance. Faster processing speed facilitated by IoT-AR solutions mitigate bottlenecks by diagnosing the problem. These solutions facilitate real-time decision-making, perform complicated jobs swiftly in one go, and connect remotely located employees. IoT-AR solution eliminates unnecessary rework, provides real-time data to fix equipment repair, and increases the operating speed.

Vision + Voice picking can play a crucial role in the order picking process. It blends both visual and audio directions to help the warehouse workers in the picking process. It helps in enhancing the picking precision and reduces the rework and errors in the process. Warehouse operators can simultaneously visualize and listen to instructions, making them clear on what should be done without any doubts. The audio-video combination not only provides the operators with audio prompts but also with visuals in their field of vision. Especially when the pickers have to pick multiple similar-looking orders from identical shelves, this technology could be a game-changer. There could be times when the voice cues cannot be heard due to the high level of noise in the warehouse, in such cases, the visuals could help the operators on what can be done next. This technology solution increases clarity in taking decisions and removes all

the barriers that slow down the work. AR wearable devices should come within built noise cancelling microphones for high accuracy in voice recognition.

Companies with multiple warehouses face the difficulty of streamlining the application, product, and process without failures and obstacles. Predictive modelling with AR and VR technologies comes into the picture here. AR and VR based predictive modelling helped companies to streamline the application, product, and process to minimize the failures without the need of operators. AR-VR based solutions are of great help when warehouse managers are not present. They can have a look at the warehouses real-time and supervise if all the processes are working fine or not. It is of great help in case of any disruptions and warehouse managers are not present. AR - VR based tools can also provide the location of freight drivers in real-time. The manager of the warehouse can also visualize the performance of the warehouse workers using dashboards and provide feedback. Similarly, the warehouse workers can view their performance in the dashboards and enhance their skills. Use of AR-VR based solutions can increase the efficiency of the warehouse processes.

Conclusion

Augmented reality is a key technology that could bring about major changes in the warehousing. It provides abilities, which can significantly enhance the productivity, efficiency, and cost reduction of the warehouse. Warehouse operations such as picking, packing, and loading as well as improving employee training are optimized, which reduce the expenses and increase income. However, currently, Augmented Reality applications in warehousing is at the nascent stage, and its potential is still being explored. Despite the development of Augmented Reality applications in warehousing, there are very few applications on a large scale. Therefore, it is very much necessary for organization leaders and warehouse managers to assess the augmented reality impact to efficiently plan out the objectives that need to be achieved. Despite the limitations, the use of Augmented Reality is picking its pace in warehouse implementation. Pick-By-Vision application will soon replace alternatives like RFID picking (Radio Frequency Identification picking) and Pick-By-Voice. With the advancement in new technology like IoT, Virtual Reality, and improvements in existing applications like Pick-By-Vision, coupled with Augmented Reality could bring about a powerful digital revolution in warehousing. Certainly, Augmented Reality can transform the way that warehouses operate in many organizations by enhancing their efficiency and productivity.

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