ACTIVE PREVENTION OF PICKING ERRORS BY EMPLOYING PICK-BY-VISION

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1 Introduction

1.1 Function and relevance of the order picking process

The order picking process is the central function of warehouse logistics and has significant influence on areas like production and distribution [1]. According to VDI 3590-1 it is defined as follows:

"In order picking systems from a total quantity of parts (the assortment) subsets (items) are assorted due to a customer order." [2]

Order picking's high relevance becomes apparent in the high costs that are caused by order picking. Depending on the industry sector logistics costs amount 5 to 8 % of revenue [3]. 50 % of the logistics costs fall upon order picking again [4].

1.2 Properties of manual and automated picking systems

Regarding the automation level there are different ways of realizing an order picking system.

Between fully-automated solutions and manually operated picking systems there are several intermediate levels in which e.g. the provision of the goods is dynamic and the deposit is carried out manually.

The most common type of picking in practice is the manual picking based on the principle of man-to-goods. In picking systems like this the goods are usually provided statically on shelves. The order picker usually receives the process-relevant information in the form of a list.

One advantage of conventional order picking is its high flexibility. Due to his cognitive abilities, the tactile sense and his ability to grasp different articles [5] human order pickers can be deployed even if the assortment is inhomogeneous or changes continuously. Companies can react to fluctuation in demand by adjusting the workforce. The disadvantage is a low picking performance compared to automated picking solutions and the fact that humans make mistakes.

Automated picking systems in contrast have a very high picking rate and picking quality. They are used when the assortment is homogeneous and when a very low error rate is required. An example is the use of automatic picking machines in the pharmaceutical wholesale [6].

Because of their high investment costs and low flexibility, automated picking solutions can't replace the conventional order picking currently, especially in small and medium-sized enterprises. Therefore, only manual man-to-goods picking systems are referred to in the following article.

1.3 Types of picking errors

In section 1.2 the high error rate of conventional order picking was mentioned as a major disadvantage. To describe the occurrence of errors usually the picking error rate is used, which is defined as follows:

$$\text{error rate [\%]} = \frac{\text{number of defective items} \cdot 100\ \%}{\text{number of items}}$$

The error rate of a conventional order picking system is on average about 0.26 %. This figure contains different types of picking errors. A distinction is made between the following types of errors [7], [8], [9]:

- Mispick: False article as a substitute or in addition to the correct products
- Wrong quantity (short pick or over pick): The number of the correct item is too high or too low.
- Omission error: An order line item has been forgotten. Sometimes the omission error is referred to as special case of the short pick error with the quantity 0.
- Condition error: An incorrect action was carried out on the product. Condition errors are often interpreted in different ways. Common examples are damaged products or improperly labeled articles.

1.4 Impact of picking errors

For companies it is necessary to design logistics processes in such a way that customer requirements are met. This applies to both manufacturing companies and logistics service providers [10]. The order picking as a major logistics process has an important influence on customer satisfaction.

In general the impact of picking errors depends on the time of their detection. This correlation is illustrated below with reference to examples.

Errors that are detected during the picking by the order pickers themselves are not customer-relevant, but still cause an expense in the form of time and costs for their correction.

This expense increases significantly when the error is detected later in an internal control, e.g. in an outgoing goods inspection. Troubleshooting in this case is more laborious because it could be necessary to re-stock a wrong item and to generate a new order to pick the right items.

If defective consignments leave the warehouse and errors are discovered by the customer, this results in a complaint and the related costs of complaint handling in the short term. In the long term, this can also lead to the loss of image and customers. Especially when production systems are supplied just-in-time, costs for subsequent delivery via express or damages for a production line stop can explode.

Undetected errors can have serious consequences. Assuming that a wrong component is installed in a vehicle or a facility, machines can be damaged or even human lives or health can be endangered.

1.5 Approaches to the reduction of errors

Because of their negative effects, especially if errors are detected too late, it is important for companies, that picking errors do not reach the customer. Therefore often outgoing goods inspections in the form of 100 % inspections or spot checks are implemented. However this kind of error avoidance is reactive, i.e. when an error is detected, a further picking process is necessary in order to correct the errors.

By using technical aids it is possible to prevent errors preemptive or to detect and resolve them immediately after the retrieval of the goods. Known solutions are Pick-by-Voice (voice directed picking), Pick-by-Light (light directed picking) or the use of handheld RF terminals, which often contain a barcode reader. For some years the Institute for Materials Handling, Material Flow, Logistics (fml) at the Technische Universität München has been doing researches in the field of Pick-by-Vision, an augmented reality based system, which provides the user with all relevant information for the picking by data glasses.

All these systems have the claim, that human flexibility can be combined with an efficient and accurate picking. In the following this issue is discussed focusing on Pick-by-Vision systems.

2 System structure and function of Pick-by-Vision

2.1 Augmented reality based picking

Pick-by-Vision is an augmented reality based picking system. Augmented reality (AR) in general implies the extension of human sensory perception. Sensors can detect environmental properties which humans can not perceive themselves.

Azuma [11] defines augmented reality by the help of the following three characteristics:

– Combines real and virtual environment
– Interactive in real time
– Registered in 3-D (spatial relationship between real and virtual environment)

According to this definition augmented reality ranges between virtual reality and real environment [12]. Whereas the user of a virtual reality system is totally immersed in a completely synthetic world, in AR systems a superposition of the real environment and virtual information takes place. This extension of reality enables the system to provide the user with additional context related information. Pick-by-Vision systems display the information which is necessary for the picking process.

A complete Pick-by-Vision system, like AR systems in general, consists of the following parts:

– Display
– Computer (scene generator)
– Input device
– Tracking system

The common type of display in Pick-by-Vision systems is the head-mounted display (HMD). The HMD is controlled by a mobile computer which is worn on the body. Depending on performance requirements the size of the computer ranges from a handheld computer, that can be worn on the belt, to a tablet PC, which is carried in a backpack. The interaction takes place via adjustment button or by voice. The selection of the tracking system depends on the application. Typical tracking systems are e.g. infrared (IR) tracking or marker-based tracking.

2.2 Pick-by-Vision without tracking system

Pick-by-Vision systems without tracking display each item line of a picking order on the HMD statically. Carrying the list, which is necessary for conventional picking, is no longer required because all information is visualized at the HMD. Besides the amount, the item number and the storage shelf (see Figure 1) also a picture of a product can be displayed.

Figure 1:Pick-by-Vision without employing a tracking system (text instructions)

A system without the use of a tracking system is not a real AR system according to the narrow definition of augmented reality, because the virtual information is not superposed in a perspectively accurate manner.

2.3 Pick-by-Vision with tracking system

For the correct perspective representation of information the user must continuously be monitored by a tracking system so that the position and orientation of the user's head are known to the system at all times. Based on this, a dynamic visualization for wayfinding in the warehouse can be provided in addition to the data of a Pick-by-Vision system without tracking.

Experiments with different visualizations [13] have shown, that a dynamically adjusting tunnel is the most appropriate visualization for wayfinding. The tunnel leads to the storage shelf where the articles to be picked are provided. Figure 2 shows the pathfinding using a dynamic tunnel visualization. In addition, the item number and the amount of items are displayed in the form of text.

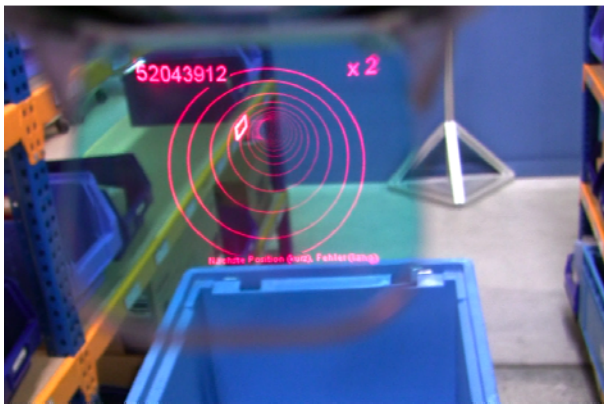

Figure 2:Pick-by-Vision with tracking system (tunnel consisting of circles guides the way to the accurate storage tray)

3 Pick-by-Vision's capability of error prevention

3.1 Error prevention with basic Pick-by-Vision systems

Already basic Pick-by-Vision systems, which are explained in section 2, are able to contribute to the avoidance of picking errors. In particular, the intuitive optical wayfinding preemptively inhibits gripping into the wrong storage shelf. As humans receive more than 80 % of the information through the visual sensory channel [14], the provision of information via the HMD facilitates an accurate information reception. The results of a laboratory test (Figure 3) confirm this statement.This is supported by the fact, that the instructions are permanently visible on the HMD, whereas e.g. the voice instructions of a Pick-by-Voice system are only available for a short period of time.

Regardless of whether the confirmation of an item takes place by voice instructions or by pushing a button, the additional step of interaction reduces the risk of omitting an item line. Comparable to Pick-by-Voice, a Pick-by-Vision system can request voice input. By comparing error checking numbers the system is able to control if the right amount or the correct items have been picked.

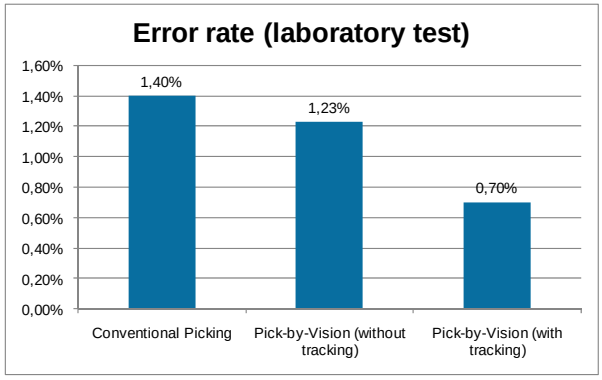

Figure 3: Error rate depending on information technology (measured in laboratory tests)

By displaying the virtual item number in the HMD, the order pickers can make a simple comparison with the item number on the retrieval unit by superposing both numbers. By comparing the two item numbers character by character the comparision can be done faster and common errors while comparing long strings, such as transposed digits, can be avoided. According to the same principle a comparison with the shape of a real product can take place by displaying a virtual picture of a product.

3.2 Upgrading Pick-by-Vision with an additional device for error prevention

On the one hand the intuitive information reception and interaction reduce the probability of single types of picking errors. On the other hand this is no guarantee

that all kinds of errors can be avoided reliably. Therefore, the Institute fml is currently developing an upgrade to Pick-by-Vision systems, which contains a control mechanism. For the implementation of the control mechanism different approaches are conceivable, which depend on whether a tracking system is used.

Pick-by-Vision with tracking has already been tested in the form of a demonstrator system using an IR target on the HMD in order to detect the position and orientation of the order picker's head. When using of such a system with IR tracking, the tracking system can be extended so that the user is monitored more exactly. In addition to the head it is possible to monitor e.g. the order picker's hand in order to observe the gripping operation into the correct storage shelf.

An ideal approach, however, is the development of a system for the prevention of errors which is independent of the use of a tracking system since the use of a tracking system is not always possible or economically viable.

One approach to this is to equip a picking trolley with additional sensors which identify the collected items during the order picking process (Figure 4). Experiments with experienced order pickers found out, that the items are often deposited with the label visible from above, so that the order picker can compare the labels with the list. Alternatives result from the use of different optical sensors (e.g. barcode scanner) which identify the collected items.

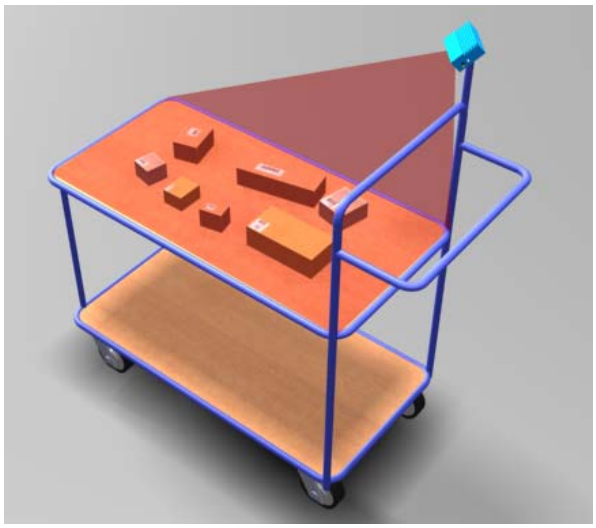

Figure 4:Concept of picking trolley with barcode scanner

Furthermore it is possible to integrate weight or volume sensors into the picking trolley. Especially when picking small components the use of weight sensors has a great potential.

A different approach is the use of the radio-frequency identification (RFID) technology. The order picker wears e.g. a RFID glove (Figure 5) in order to detect picking errors [15]. Besides labeling the providing unit with RFID transponders in order to verify the gripping operation also every single deposit unit can be tagged with a transponder, which allows a more extensive and detailed testing.

Figure 5:Picking with RFID-glove

Independently of the selected control mechanism, the user gets a feedback in case of an error in two different ways: Visual feedback on the HMD and functional, so that the order will only continue, when the error is corrected.

4 Outlook and conclusion

Currently various concepts for the function to avoid picking errors are elaborated and preliminary tests with different technologies are performed. After the search of suitable components for the implementation a demonstrator system will be established. A main criterion is the consideration of the perspective of the system's potential users because acceptance is one of the major problems of current AR systems. Finally, the demonstrator has to be tested in both laboratory tests but also in practical tests in cooperation with industrial partners. In this way an applicable system can be designed.

Due to its high flexibility conventional order picking is currently the most common way of order picking, even if human order pickers cause errors. Since picking errors weigh heavily on the customer-supplier relationship and cause high costs, it is important to avoid them. In initial tests the order picking technology Pick-by-Vision has shown, that this technology can be used not only to increase the picking performance, but also for preemptive avoidance of errors. The Institute for Materials Handling, Material Flow, Logistics at the Technische Universität München is developing an active system to avoid errors based on Pick-by-Vision. By the help of this system errors can be detected and

removed right at the location of their origin. The vision is to upgrade the Pick-by-Vision system in such a way, that an approximation to zero-defect-picking can be achieved - which currently can be reached with automated picking solutions only.

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