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CAN THE MOBILE ROBOT BE A FUTURE ORDER-PICKING SOLUTION?: A CASE STUDY AT AMAZON FULFILLMENT CENTER

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Abstract. In logistic operations, picking is the process of finding products to meet different orders. Therefore, improving automation and work performance is a focus on logistic operation. The purpose of this study is to describe a system that can improve efficiency at the Distribution Center by using Kiva Robots. That is a system that can help humans reduce walk time and labor costs which must occur, and identify the concepts of applying multi-robots at the Amazon Fulfillment Center. Kiva Robots are here to answer the problem of order picking at the Amazon Fulfillment Center.

Keywords: Kiva robot, Fulfillment center, Amazon, Robot Mobile, Picking System

1. Introduction

In industrial development 4.0, the Internet of Things (IoT) has a rapid development that can help human's activities and change human's interaction with the environment. IoT technology is currently taking an important role in the socioeconomic communityas well as the robotic system. So, it is a new concept that combines the two is called the Internet of Robotic Things (IoRT) (P.P. Ray ,2017) (C. Razafimandimby, V. L. ,2016) (Batth, 2018) (Yan Liu, W. Z. ,2020). Industry 4.0 has an influence on operations in the Distribution and Fulfillment Center. In addition, picking is an important activity in the Distribution and Fulfillment Center because it requires most funding; therefore, an effective process for its operation must be carried out.

Amazon has created the latest logistical model "Shelf to The People" using the "Kiva System". This new system significantly contributes to the development of the picking process. In 2012, Amazon bought Kiva System for USD 775 million and started implementing the System In August 2015, the company officially changed its name from Kiva System to Kiva Robots or Amazon Robots (Nussbaum, R. ,2015). Even though it still requires human labor in its operation, Kiva Robots are considered more effective in helping the work process What is more, Kiva Robots only help human work, and it does not eliminate the human position itself. Hence, the cost of time that pickers used to walk, can be reduced by using Kiva Robots. What is more interesting is that the Robots can carry these shelves independently to the human pickers who will take goods from the shelves and Amazon's employees only need to stand at a fixed point to complete their work.

Compared to the traditional Distribution Center, Amazon Kiva System is a new multi-robot system designed to take over ATS (Automatization Tridimensional Storehouse), Long Distance Belt, Conveyor, Carousel, etc. Kiva Robots are only 76 cm long, 64 cm wide, and 41 cm tall. In addition, the Robots can carry a ton of objects despite their small size. These Robots can even find charging stations to recharge their energy when it is running low. With the help of these robots, the overall time efficiency of picking has increased from 3.5 times to 5 times (Zhang, X. M. ,2015). Kiva Robots appear to answer the problem of fulfillment order at Amazon companies. The purpose of this study is to explain how Kiva Robots work in the Amazon Fulfillment Center and identify the concept of the system starting from the application of multi-robots to the Amazon Fulfillment Center.

2. Literature review

Internet of Robotic Things (IoRT) iss an integration involving smart environment and autonomous agent (robot) capabilities as a new intelligent technology which is capable of

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monitoring activity using sensors (RFID connected to the Internet of Things (IoT). Furthermore, this new concept has brought some changes in different environments that include the use of multiple applications (Ilya Afanasyev et al ,2019). IoT focuses on support services for widespread detection, monitoring, and tracking, while robots focus on production and interaction (Matthews, K. ,2019).

Smart Logistics or Logistics 4.0 is an implementation of the enhancement and of the use of IoT, which allows for the occurrence of real-time communication among products, machinery, services and human beings, and the use of advanced digital tools (L. Barreto et al, 2017). Therefore, smart Logistics relies on the use of technology applicationsso that it can enable effective planning as well as the efficient resources and management of warehousing and transportation systems to ensure efficiency in transferring data and materials among departments.

The adoption of industry 4.0 will introduce a great change in a way that the warehouse system works today. In addition to the implementation of Warehouse Management Systems (WMS), it will transform warehouse activities into the future with automated operating systems with modern technological implementation (L. Barreto et al, 2017). Thus, the achievement of logistics distribution systemsis on high efficiency and low costs with intelligent operations.

Robotic Mobile Fulfillment Systems (RMFS) are automatic or (unmanned) vehicles, a new type of robotics. Part-to-picker material handling system moves along the floor and takes materials to the pickers (M. Merschformanna, 2019).

Amazon Kiva robots are designed to meet consumer’s demands in e-commerce by using a better system to provide order fulfillment solutions with IoT incorporating robots that make it more convenient, more effective, and faster for real-time e-commerce processing through automation. With a connected WiFi networks, robot can follow the commands that have been given through the control of the software (Jun-tao Li, 2016).

Besides, the Kiva robot has the ability to recognize objects by using navigation-monitoring. In order to read the QR code of the path on the floor, and two cameras are installed in each robot. Also, each shelf also has a bar code on the bottom of the shelf in order to ensure the actual shelf accuracyfor the right position of the robot (Jun-tao Li, 2016).

3. Method

This study used qualitative descriptive analysis starting with (i) describing the 4.0 logistics system in the warehouse (ii) explaining and analyzing the work process and the design of the Kiva robot as well as a description of the concept of multi-robot (iii) analyzing the impact of Kiva on Amazon company.

The provisional charge/statement of this research is that the implementation of the Kiva robot on the Amazon warehouse carries the advantages and disadvantages to the operational fulfillment order at the fulfillment center.

The data used in this study was secondary data. Additionally, it was obtained from previous literatures, international journals and various mass media in both printed and electronic forms.

4. Discussion and Result

4.1 How Kiva Robot Works

The Robotic Mobile Fulfillment System is a part-to-picker system using movable shelves to store items and using robots to ship the shelves to the picking stations. As shown in Figure 1, a robot’s delivery task involves five steps (Jingtian Zhang, 2019).

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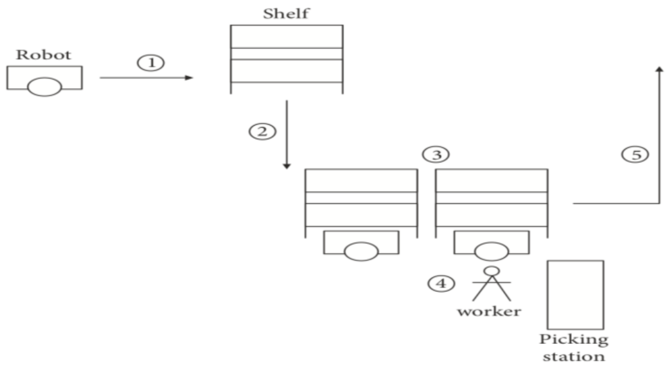

Figure 1. *Five steps of a robotic shipping task. (Source:* Jingtian Zhang, 2019)

Kiva Robots complete the order task in five steps, as follows:

(1) Driving from the robot’s current location to the storage location of target shelf .

(2) Carrying the shelf from storage location to the picking station.

(3) Queuing on the buffer of the station until the shelf ’s turn.

(4) Letting the worker pick products from the shelf.

(5) Bringing the shelf back to the storage location.

4.2 Design of Kiva Robot

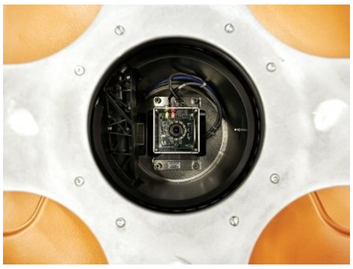

Figure 2. *Navigation System of Kiva Robots (Source:* Guizzo, E. ,2008)

Their innovation is to embed two cameras as a navigation monitoring tool, and the purpose is to be able to read the code. Moreover, the camera above is used for navigation, and the QR code label is attached under the rack pod. The camera detects the code of the tracking sticker on the floor (Dou Xin-Xin, 2016). Then, Kiva robots will move asthey read the information on the code line stickers on the floor to learn their coordinates in the warehouse. This control system regulates the robot to always follow parts of the stickers on the warehouse’s floor forming a path so that the body does not exist from the center of the available path.

The sophistication of the design of Kiva robot system can be operated accurately by following the identification code on the floor in the distribution centerin order to avoid mistakes caused by collisions between each other. When Kiva robots are designed,there will not be more than ten robots failing at the same time at each layer of the warehouse; Therefore, the work accuracy of the Amazon Kiva robot can reach a number of 99.99%, which can greatly reduce the probability of human’s error (Jun-tao Li, 2016).

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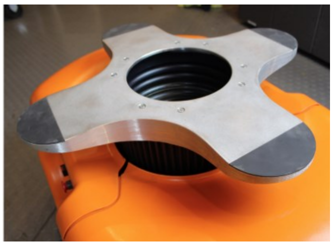


Figure 3. *Lifting mechanism.*

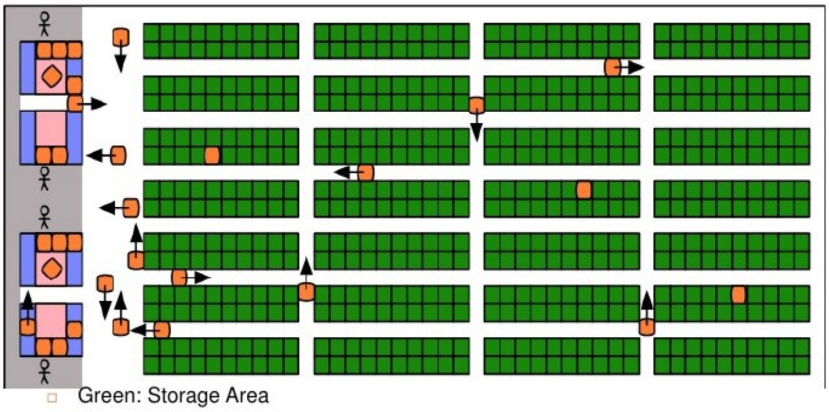
Figure 4. *Power system charging.*

Figure 5. *Collision detection system*

(Source: Guizzo, E. ,2008)

Lifting mechanism with a large screw turns to raise racks of inventory as high as five centimeters from the ground. At the same time, the wheels make the robot rotate in the opposite direction to keep the rack motionless (Figure 3). Power system with four lead-acid batteries propels the motors and onboard electronics. When batteries run low, the robot automatically moves to a charging station (Figure 4). Collision-detection system infrared sensors and touch-sensitive bumpers stop the robot if people or objects get in its way (Figure 5). Driving system with two brushless DC motors control independent neoprene rubber wheels which allows the robotsto move at 1,3 meters per- second (Guizzo, E. (2008).

4.3 Overview of Multi-Robots in Warehouse



- Green: Storage Area
- Orange: Mobile Robots
- Blue: Stations

Figure 6. The Operation of Kiva Multi-Robots in Warehouse (Source: Peter R. Wurman, 2008)

The application of the concept of multi-robot in the warehouse is very useful considering the many benefits and advantages given compared to using the traditional way of warehouses that employ many people in the fulfillment center area and still use the material handling machineries such as forklift and Conveyor.Therefore, the concept of multi-robot provides a very profitable impact on the optimization of voters. Because Kiva robot's speed is much faster in running and picking up goods in the Fulfillment Center area, the precision and accuracy can be offered (Jun-tao Li, 2016).

Kiva Robots work to;

1) Perform tasks, 2) be released to the next round when the task is completed, 3) Wait for performing the task.

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The concept of multi-robot in the warehouse is actually applied due to the optimization of the way the robot that works in the warehouse and acceleration of the order fulfillment. Therefore, multi-robot task allocation can effectively reduce the cost of time in step one, andimprove the efficiency of the entire work system of Kiva robots.

4.4 The Impact of Kiva Robot in Amazon

The results of the research on Kiva robot's implementation have a tremendous impact on the modern center and can hold 50% more inventory than the old warehouse (Bouge, R. ,2016). Plus, Kiva can provide an efficiency in time and expense in the Fulfillment Center, which are the main reasons for Amazon's investing in Kiva robots in the warehouse. In the first year, Amazon used the Kiva robot in the warehouse, it gained a difference in profits generated after the implementation of Kiva robots in the warehouse.

At the beginning, Amazon adopted Kiva due to the emerging problems encountered in Amazon, such as the inability of the management system at inventory management to cope and fulfill orders in a timely manner so that there is a delay in delivery to customers. In terms of competition for business positions, with many other e-commerce companies, Amazon enhances its way to be able to take experience and customer 's satisfaction in to account (Dr. Dhiraj Jain, 2017).

Theadvantages, of Kiva robot is that it provides benefits for the Amazon distribution center and fast-increasing orders by consumers, and the robot is capable of handling thousands of stocks compared to humans (Dou Xin-Xin, 2016) (Xiaoqing ,2020). Moreover, the application of the concept of multi-robot or the addition of robots on Amazon clearly provide the significantly increasing quantity, quality, and speed of service delivery better than the previous one. In fact, robot adoption helps increase workforce productivity as well as reduce operating costs by 20% ((Jun-tao Li, 2016) ((Dr. Dhiraj Jain, 2017) (Bouge, R. ,2016).

However, its shortcomings also still exist in the warehouse. In the operation of Kiva robots, the condition of the system using code stickers on the floor should always be clean in order to remain readable, and the robot does not stop at the time of the order.The constraints also occur on the bar code sticker at the bottom of the pod shelf that should always be legible so that the robot can read the code (Hanson, 2018). If the robot is in the maintenance process or within the battery-charging period, it may reduce the amount of productivity at the Fulfillment Centre (Hanson, 2018).

5. Conclusion

Along with the development of the logistics and technology industry, Smart Logistics changes the traditional logistics way with a new system that combines technology and robotics and have a real impact on the logistics world. Moreover, it can help reduce the cost and increase business competition. The presence of Kiva Robots in the world of robotics provides a new automatic picking solution. Kiva Robots can carry these shelves independently to human pickers who will take goods from the shelves and Amazon employees only need to stand at a fixed point to complete their work, compared to the traditional Distribution Center.

Amazon Kiva System is a new multi-robot system designed to take over ATS (Automatization Tridimensional Storehouse), Long Distance Belt, Conveyor, Carousel, etc (Zhang, 2015). Therefore, making Amazon optimal by using many robots with multi-robot systems brings about more effective and efficient work because the impact given by robots can save time and speed up the fulfillment of customer's orders on e-commerce. Nonetheless, Kiva Robots also have disadvantages. The thing to note is that the bar code sticker on the floor must be kept clean and is not damaged so that the robot can work properly, and charging Kiva Robots takes a long time, so it will reduce the productivity of the Amazon Fulfillment Center.

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