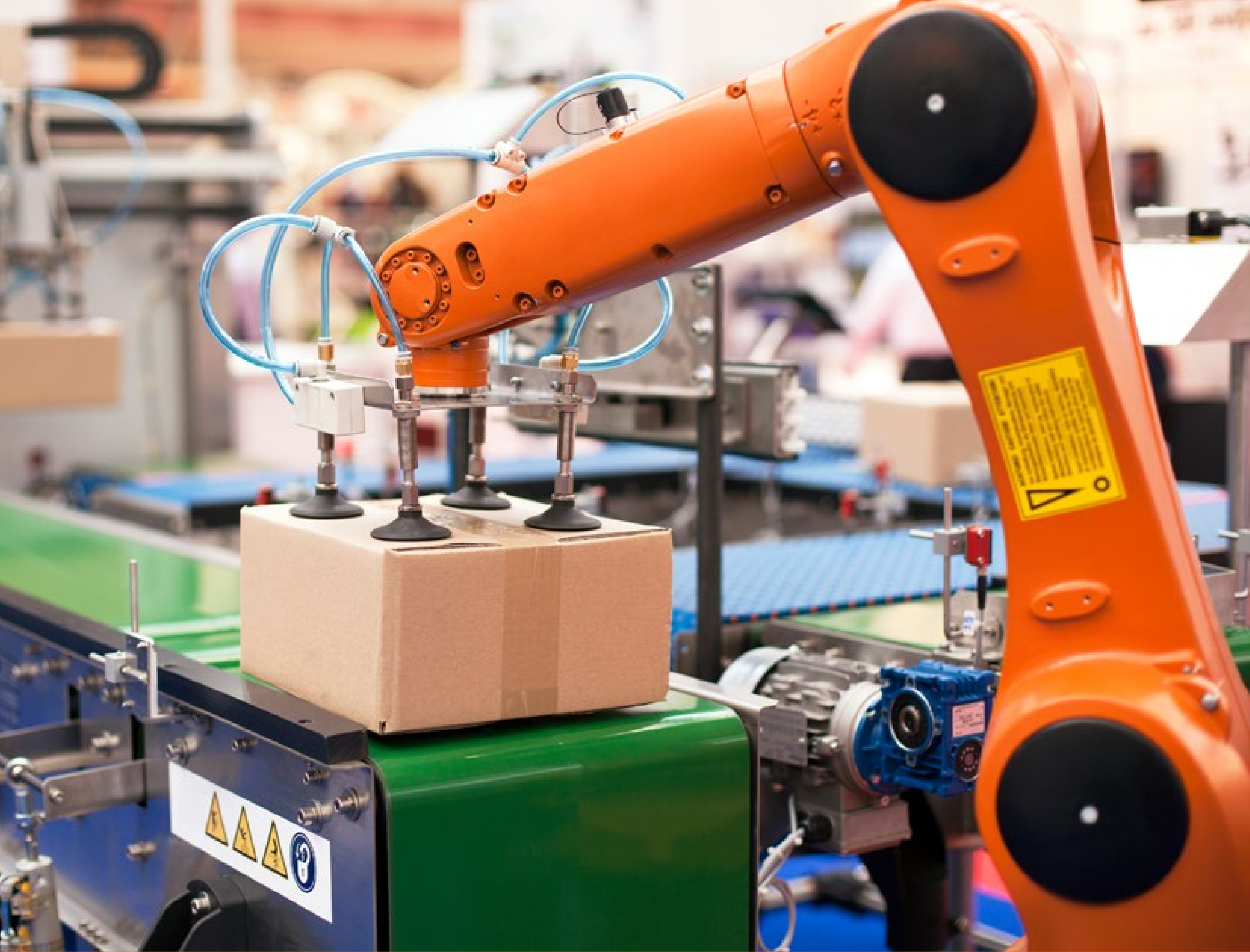

# Fulfillment Center Automation:
# Making Way for Pick and Stow Robots

Holiday hiring was pretty flat in 2016. The numbers were big though; Amazon topped the list with an estimated 120,000 new hires[1] while Target hired 70,000 in its stores and another 7,500 at its distribution and fulfillment facilities.[2] Of interest is the trend of retailers reserving a growing percentage of about 10% of the hires for online orders and tele-service departments. Logistics follows a close second to retail on the hiring front. UPS announced hiring 95,000 people to help meet peak shipping demands. Clearly, holiday hiring is moving from brick to click and from storefront to warehouse.

Unfortunately, this hiring scope did not excite most job seekers. While retailers are doing their best to offer attractive packages (with retention policies, bonuses, discounts, ride sharing, and more) at the expense of rising costs, the jobs themselves are monotonous and tiring. Fulfillment centers can be a million square feet in size and in a single shift of 8–12 hours, a worker can traverse as much as 7–12 miles. With more than 400 orders to fulfill per second, each employee will have to put together an order in under a minute. What's more, with billions of pieces in the inventory, including 'smalls', ensuring accuracy is not only important but also stressful for workers.

## **Automation:** Last Mile Hurdles

The biggest retail fulfillment centers today employ a fair bit of automation. Hardware such as conveyor belts for totes, smart shelves, robots to carry shelves to pickers, voice directors that read out orders, pick mods or handhelds that flash the order, pick-to-light and stow-to-light systems that guide pickers by light are all examples of such automation. Similarly, most retailers deploy sophisticated software at warehouses including warehouse management and control systems, digitized inventories, automatic pack sizing, object recognition, item finding, and order tracking. Despite these advancements, the last mile is still a challenge. Amazon's Kiva robot can move a whole shelf, but if fulfilling an order requires picking several disparate items such as a baseball bat, a video game, and a T-shirt, it still requires human intervention.

While industrial robots have been providing sophisticated automation for manufacturing, replicating this in a retail warehouse poses several challenges. First, the robot must be able to move, if it has to replace a 'picker' who moves to pick a piece. Second, there are typically a million different pieces in the inventory, of different shapes and sizes, including soft objects like clothing that do not have a fixed shape, making these difficult to identify and pick. The third major challenge comes from packets that are stacked one behind the other or one on top of the other, leading to occlusion. So, how can retailers overcome these challenges to use 'pick' robots to their advantage?

## Looking Under the Hood

To understand the underlying technology, let us look under the hood of a 'pick' robot. It essentially consists of modules, as shown in Figure 1.

Here is an overview of the robotic picking process:

1. A one-time activity, system calibration, helps the robot learn its position with respect to the rack, its bounds, and the reach of its arms for a given location.
2. Once the system is calibrated, the robot is ready to receive orders for picking items from the rack.
3. By using its perception module, the robot recognizes the corresponding object on the rack and determines its physical location in the real world.
4. This information is then utilized by the Motion Planning module to generate a path that the robot end-effector (tip of the hand) can take to reach the object.
5. Once the end-effector reaches the desired location, it uses a gripper or suction mechanism to lift the object.
6. Finally, the robot performs a check using various sensors to make sure that it has done its job correctly. In case of an error, it goes back and repeats steps 2–5.

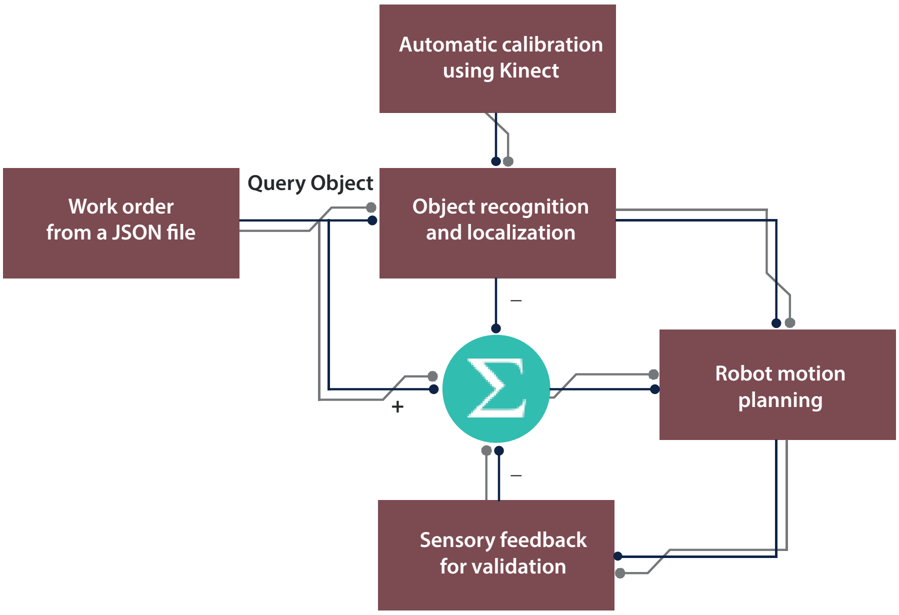


*Figure 1: An overview of the modules in robotic picking*

To do all this, the robot requires a special assembly of parts and training. It needs 'legs' for mobility (wheeled platform) and an arm that has several joints, enabling different movements. It needs an end-effector that can pick up objects. It also needs motion detection sensors and numerous electronic parts that help it move, see, and grab. The robot has to be trained to recognize objects—a slow and laborious process where scanned images of each object from various angles are fed into it. Thereafter, using perception algorithms that leverage deep learning and other machine learning techniques, a robot can be trained to make sense of the world around it.

Robotics success needs the support of multidisciplinary skills. It requires expertise in multiple domains such as mechanical engineering, mechatronics, and computer science specialization in areas such as control, vision, and machine learning. In addition, there are several small parts and circuits, which require engineering expertise of high caliber. A system integrator is vital for robotics. In fact, integrating even a smart robot can be complex and considered a 'research' problem. For instance, how does one ensure that the robot takes the minimum time to pick an item? Can it match human dexterity and speed? How does it deal with errors? Remember, it has no control over the objects it can come across or how they are stacked. Is it possible to pre-feed all possible combinations of stacking? Or, can there be a certain level of uncertainty that the robot should handle on its own?

## **'Picker' vs. 'Sucker':** Settling the Debate

As of now, neither picking nor stowing of objects using robotics has been mastered at an industrial scale. Robots do drop pieces and cannot figure out occluded objects. It is not clear if one arm is enough or if two are required. The jury is out on how many joint movements (or degrees of freedom) would be ideal for each arm. Currently, suction is popularly used to draw objects up. In the 'picker vs. sucker' debate, picker robots or at least hybrids, are likely to win. Gripping and grasping with digits will have to happen sooner rather than later, given the nature of 'smalls'.

As for the big picture, a question that is difficult to answer is whether robots should move or the containers and racks containing merchandise should. How well can robots work with humans? Currently, they are able to stop when they come close to humans to avoid bumping into them. Can robots understand if a human were to show them where to put things and successfully accomplish the task? Retailers will definitely benefit if one operator can manage the whole warehouse sitting in a cabin, instructing individual robots in the aisles to perform tasks.

For this dream to become a reality, robots need to learn faster. Writing complex code on the fly for them may not be possible and it's definitely not efficient. They must be able to learn from 'teaching by demonstration'—where an operator physically demonstrates to the robot how to carry out a task. Robots must also be equipped to learn from other robots and humans (connected through the Internet) that have solved a similar problem. Finally, they must be able to pick up unusual occurrences in the warehouse and communicate the information to humans as well as other machines.

## A Robotics Resurgence

While these seem like big problems, researchers are full of hope as robotics is charging ahead in massive leaps. Demand, such as what we see with the growth of robots in eCommerce, is surging. The price of several components such as sensors and parallel processing GPU has fallen. In terms of software, the maturing of Big Data and deep learning technologies is furthering Artificial Intelligence (AI). Industry 4.0 capabilities leveraging the Internet of Things (IoT), cloud, and robotics are also amplifying the growth in AI and robotics.

These advancements strengthen the case for warehouse robots by the day. Until last year, their perception and cognition capabilities were considered huge problems. Now, the perception challenge is likely to be solved, following recent advancements in deep learning techniques. Robotic 'grasping' is still going to be a challenge but we can expect to witness breakthroughs on that front too. Google is already developing a system where robots are learning difficult tasks like path planning and grasping through repeated experiments using techniques such as deep reinforcement learning.[3]

The pick and stow robots seem to be within arm's reach, with both academic and industrial institutions investing heavily in their research. Before this decade is out, CIOs will have access to not just the heavy lifting Kivas, but also their nimble pick and stow cousins.

## About the Authors


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