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Just Walk-Out Technology and its Challenges:A case of Amazon Go

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***Abstract*— the current research looks at the work of new technology called "Amazon Go". The Shopping experiences are becoming more revolutionary, first there was the introduction of the supermarkets shelves, then came the barcode scanners, then arrived the self-checkout lines and then the online shopping. With this revolution in shopping Amazon comes with a complete new kind of shopping style with just Walk-out technology. The present research involves about the technology used in Amazon go store, how it is implemented and the details about how it actually works. This paper further discusses about the challenges that can be faced on implementing this new technology and suggestions to overcome these challenges.**

Keywords—Amazon Go, Cluster analysis, RFID, Sensor, Deep Learning, Computer Vision

Introduction

In recent years, online retail has exploded at an astounding rate, yet the majority of people still actually prefer to shop-in store. The fact that moving online completely in certain categories of shopping is not likely possible. In such cases, buying the items from the shelves store-in seems to be a more attractive proposition. Amazon Go is a new kind of shopping sense with no checkout required. This advance technology is an attempt to bridge the gap between online and offline world. This is the advanced shopping technology with Just Walk out Shopping experience, no need to wait in line. Simply get the app, get into the store, take the items you want, and just go! No annoying queues for checkout process.

I. WHAT IS AMAZON GO?

Amazon Go is a real world grocery store that comes with the twist, there's no checkout process. Simply have to grab the stuffs you wish and walk out; the order is directly charged to your Amazon account. There aren't any lines, no cashiers, no bungling for credit cards nothing.

II. WORKING OF NEW KIND SHOPPING EXPERIENCE

Simply scan in, take what you want and "Go". Every customer entering the Amazon store would be tagged upon entry to shop. Visitors tag their smartphone with the store, which contains the Amazon Go app, as they enter the retail outlet.

Photos are been taken when customer enters the store, when customer pick any products from the shelf, and when they left with products while leaving. Facial Recognition and customer information is traced which may include images of the user, details about the customer such as height, weight and user biometrics. That then allows the store's surveillance system to identify the customer so that it can track them as they move throughout the store. Cameras picks up images of the customer when they come in front of shelves, of the items they picked up and whether the item picked stayed in customer's hand or kept back in the shelf. Sensors placed at shelves automatically detects when the product are taken from shelves or returned to the shelves and keeps track of the products in a virtual cart. Virtual Shopping cart are maintained for each individual Amazon account User.

This advance shopping technology completely eliminates queues and checkout. Upon leaving the store, customers will be charged on their Amazon account and get a receipt generated automatically.

Below figure shows how all of these various sensors collaborate to track products and customers.

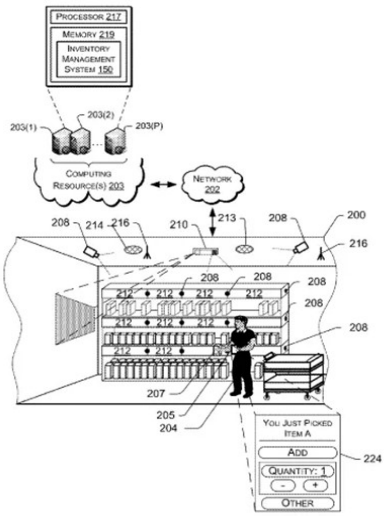

Fig 1: Detecting item interaction and movement [4]

TABLE 1: HARDWARE AND SOFTWARE REQUIREMENTS FOR IMPLEMENTATION

	Person	Shelf	Entrance/Exit
Hardware	Smart Device (Smart Phone)	Cameras, pressure sensors, infrared sensors, scales, volume displacement sensors, light curtains, etc.	2D Barcode
Software	Amazon Go app	Warehouse Management System(WMS)	Customize system

Amazon Go has executed the combination of

- Big Data - 20 years of customer buying patterns on Amazon.com
- Analytics - both predictive and prescriptive analytics
- Deep Learning - self learning algorithms trained for retail using troves of data
- Internet of Things - sensors, camera, RFID tags, etc.

III. TECHNOLOGIES USED IN AMAZON GO

It is an amalgamation of technologies such as:

- Artificial Intelligence
- Machine Learning
- Image Recognition
- An array of "Fusion sensors"
- Decades of data on how humans shop

Amazon Go's Auto-Checkout shopping experience is made working with the same kinds of technologies that are been used in self-driving cars: deep learning algorithms (DLA), computer vision (CV) and sensor fusion.

IV. TECHNICAL WORKING OF AMAZON GO

STEP 1 : Data Acquisition

Sensor fusion from sensing element or sensor data acquired through several sensors on aisles, which will help Amazon to identify what items, has been picked up from the aisle or shelves:

Some sensors whose data Amazon will "fuse" are the

- Pressure detector/sensor
- Weight measurement
- Unique Identifier through RFID tags
- Distance & Dimension measurement that will track what/when items are being picked up or kept back on the shelf
- This will help Amazon slender down the item from its inventory based on the Array of cameras for image/video data
- Where are the sensors expected to be placed?
    - On the aisles/shelves to know what's being picked and wherever the product is being moved
    - Cameras would be placed all around - aisle, rack, store walls, etc.

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STEP 2: Analysis of acquired data using AI

- Deep Learning (DL) algorithms that takes in huge quantity of data to train "self-learning" algorithms to understand whether
    - The product has gone into the cart?
    - Customer has put the product back on another shelf after picking up?
    - how long a customer holds/observes the product before making the purchase decision
    - what products are being sold -> what is the best place to position the product to ensure customer finds it easily and product is sold quickly
    - Product/SKU optimization -> keep only the in-demand products and discard products/SKUs (Stock Keeping Units) that customers do not like.
- Analytics: Sensor data + users past purchase history could be used to evaluate whether the product just picked up is tomato ketchup or a bottle of oil.
- Confidence scores and hypothesis testing can help with that.

STEP 3: Finally, present the result of automated analysis by intelligent machines

- In the form of adding the items to the virtual cart of Amazon customer as soon as the customer passes the transition area.
- Generating the final bill

V. NEXT-GEN OF RETAIL SHOPPING

A. Data-driven product Display

Amazon is able to track the movements of the shoppers within the store. Artificial Intelligence can then be able to learn from shopper's flows, as where to display the items, how to showcase the products to extend the shopper's cart size, and maximize the sales.

B. Better assortment renewal

Amazon will gather data about when an item is taken by the shopper. Deep Learning Algorithms is able to outline what are the most effective times, volumes and products for assortment renewal, so as to decrease prices and guarantee permanent shoppers satisfaction.

C. Extreme Personalization of Services and Offerings

With in-store tracking, Amazon will be able to master Omni channel merchant. By having knowledge not solely concerning their customers as net visitant, however additionally as store visitant, Amazon will be able to fine-tune at a really granular level, that's how it targets its customers.

D. Reduce value & improve quality

Checkout queues are usually each one among the big source of costs for the retailers, and a source of frustration for patrons. By applying AI, Amazon may simply manage to eliminate each in one fell swoop.

VI. CASES WHERE AMAZON GO CAN GO WRONG OR FACE CHALLENGES

A. What if the customer use mask? Or what if he removes or wear jacket in the store? Will Amazon Go identify the Customer?

It is clear that Amazon Go uses Computer visions and Fusion sensors to record and analyze the each of the human motions. So if the customer uses mask, wears or removes the jacket and all will all be captured and it doesn't leads to confusion to identify the customer.

B. Will the customer be charged on returning the products to different shelves, not from where it has been taken?

When a customer picks up an item it reflects the virtual cart of the customer, and when he puts back an item on wrong shelf. So here there's some provision for the user to remove items manually and put back on correct shelf, but this is not possible always. So there is a need for the shelf to detect a foreign item and guesses which item of which shelf, or a computer vision backup system corrects the mistake. Or maybe there are RFID readers constantly counting the items in each region or shelves of the store, which will be able to correct the mistake as soon as the customer walks away from the shelf or put backs on other shelves.

In this case, the customer won't be billed when they walk out of the store because the RFID readers won't see the items leaving from the store. This will be an extra check of the products.

C. What if the customer takes the fresh juice bottle from the shelf and replaces it with an empty bottle? Or else consumes there itself and keeps the empty bottle back on the shelf. Will Amazon Go identify it?

There are many observing cameras all around the stores and shelves, but much cheaper solution would be a weight sensor under each shelves. All the items on one shelf section have the same weight. When the customer consumes the juice bottle there it and keeps the empty bottle back, will still be billed as weight sensor and cameras will identify the misbehavior of the customer.

D. Will Shoplifting or cheating in the store be recognized?

Even preventing shoplifting in supermarkets are been difficult but this has been solved almost by Amazon Go through a number of advanced technologies used in it. The most fundamental is the use of hundreds of image sensing cameras. Using advance technologies like machine learning and artificial intelligence, Amazon Go can detect an item that is not only missing the store shelves, but also being held in user's hand, put into the bag, or even under the shirt.

E. It is seen that currently Amazon Go reportedly breaks if quite 20 peoples are within the store.

Amazon's Go store presently only functions if there are fewer than 20 shoppers within the store. Any more than that Amazon's shopper-tracking technology breaks down, as individuals become too troublesome to follow. As each and every RFID tag has a unique ID and every item is tagged with this RFID and a unique Id with the customer then separating individual tags - out of a shopping cart containing multiple tags is not that difficult. So even if more people are checking out of the exit lane it will be properly match with the correct customer because of this RFID tagged with the customer.

F. How will *the children of one shopper be figured out? As children does not have smart phone, the items picked up by the children will be charged in whose account?*

This is really a challenging case for Amazon Go to put items picked by the children in their belonging's cart. As children does not have any smart phones with them. So there must be a tagging of children with the parent at the time of entry itself. So that items picked in this group is placed in one cart.

G. *How to figure out which item belongs to which customer? E.g. Customer A picks up item B, and hands it to customer C in the aisle. So customer's C virtual shopping cart should reflect item B.*

In this case Computer Vision might be the right hammer for this nail, as the exchange of items may be done in the camera's blind spot. T the right tool here is RFID, and RFID

detectors all over the retail space. This is true only if you want to show items in the customer virtual cart in real time. Else just have this RFID map in the exit area (the "transition" area). AI can associate specific item location with the customer location as tracked by AI. However nobody wants to piss off paying customers hence the existing solution must allow for the above scenario. So every item will have a location tracked in the RFID map, and every customer's motion is tracked by the camera and assigned a location in the RFID map (as customers cannot be RFID tagged). Then there is no need of advanced Artificial Intelligence (AI) to figure out which items belong to which customer, a simple cluster analysis will do the job.

Once the customer goes out of the store, the bill gets generated. As everything is tracked, the store balance sheet must match up in real time. That is items not in the store shelf must equal the items in the customer's virtual shopping cart. When the customers exit, the balance must again be reflected correctly in the system. If there is a discrepancy, retail security will be immediately alerted.

VII. CONCLUSION

Shopping on-line is nice and super convenient; however in some instances there is still no substitute to better old brick and mortar shopping stores. Amazon Go is geared up to revolutionize the shopping method by streamlining shoppers flow with innovative technology and by removing the foremost dreaded link of checkout counters in the offline shopping chain.

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