Use of AI and IoT to make Retail Smarter

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2022 3rd International Informatics and Software Engineering Conference (IISEC) | 978-1-6654-5995-2/22/$31.00 ©2022 IEEE | DOI: 10.1109/IISEC56263.2022.9998202

Abstract—Technological advancements the industry is expected to spend 7.3 billion per year on artificial intelligence by the year 2022 and Retailers that are looking to stay one step ahead are increasingly turning to artificial intelligence and IoT to help them understand the millions of data points in store and turn them into insightful information that they can use to improve speed and effectiveness of their business decisions. This paper talks about how AI+IoT (AIoT) can combine to provide powerful digital transformation experience in Retail Stores. This paper also explores what are some examples of current AIoT implementations in Retail Stores around us and what some of the newer ways in which Retailers can adopt AIoT and drive operational excellence. We will also deep dive on one such example, Electronic Shelf Labels (ESL), how these are revolutionizing pricing in stores and some real-world examples where ESLs are driving efficiency.

Keywords—Smart Retail, AI, IoT, Internet of Things; labels; ESLs; Electronics Shelf Labels; Wireless; BLE; iBeacon

I. INTRODUCTION

With the rise of new technologies, the gap between physical and online is closing. There have been many advancements made to the physical Retail stores in the recent years due to Covid Pandemic. Smart brick & mortar stores have kept themselves ahead of the curve and were quick to adjust to the Covid pandemic with shop online pick in stores and touchless experiences. One of the most important reasons Retailers have been able to quickly adapt to these changes is due to adoption of Digital Transformation efforts put in by these Retailers. Internet of things (IoT) has been in the forefront of this Digital Transformation. The IoT refers to the network of physical devices connected to the internet that can collect, store, share, and interpret data.

In addition to IoT, one of the biggest advancements in the tech world is the rise of Artificial Intelligence (AI). The AI technology has been used in everything from computers to medical devices, and it will only become more prevalent in our everyday lives. The potential applications for AI are almost limitless, and the technology is already impacting a wide range of industries. Retail Industry has seen significant impact due to investments in AI. 28% or more Retailers have already deployed Artificial Intelligence/Machine Learning solutions which is a 4% increase from 2016.[1]

Combination of AI and IoT (AIoT) opens significant opportunities for the brick & mortar stores. By combining AI and IoT stores can collect massive amounts of data and process them closer to the customer and reduce cloud round trip times.

II. CONVERGENCE OF AI AND IOT

IoT and AI have been in the marked for some time. However only recently Retail Tech industry is unravelling the power of combining both AI and IoT. The convergence of AI and IoT is commonly referred to as Artificial Intelligence of Things (AIoT). AIoT is AI-enabled IoT that enables improved understanding of the machines and pattern of their operations, thus rendering predictability, smarter controls and seamless connectivity resulting in appropriate, prompt, and corrective actions with little or no human interference.

IoT enables large scale collection of data through smart sensors, smart devices and AI enables processing of this data closer to the customers, physical space and make smarter decision on the fly. These decisions can then be converted into actionable insights for Retailers or wherever they are deployed bringing much faster decision times and quicker response times. In essence, AIoT can bring the aspects of human thought-process and intelligence much closer to the physical space which was usually a much slower process due to training data and supervised learning historically and thus building a system that is smart enough to make decisions.

More specifically, AIoT is altering Retail operations in ways that dramatically increase store efficiency, drive more productive, happier store staff, and create a better, more personalized shopping experience for customers. Workforce management, planogram management, inventory fulfillment, computer-vision shelve scanning to cashier-less checkouts and in-store shopping experiences is driving significant investor interest back into physical retail.

III. WHY SHOULD WE USE AIOT IN RETAIL?

According to Gartner 80% of IoT projects will have an AI component. Together they are expected to expedite the digital transformation of various industries on a global scale. [12] Retailers can significantly improve and streamline their store operations by means of AIoT. By deploying sensors, smarter controls and increased sources of data (business and customer) collection, retailers can take advantage of the capabilities of the technologies. Also, according to a report by SPD Group on The Value of Artificial Intelligence for Retail in 2022, one AI vendor claimed a 32% reduction in operational costs after implementing AI-driven solutions.[1]

The report [1] also claims:

- 49% of respondents expect that AI will cut costs in the supply chain.
- 44% expect that AI will boost productivity.
- 43% are sure that AI will be a major factor in boosting revenue.
- 40% recognize the use of AI in retail decision-making as the main benefit of the technology.

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IV. Real world applications of AIoT in Retail

Cost of acquiring IoT sensors, devices and low-cost mobile phones is much more economical than before. Their adoption in Retail industry where one store can deploy hundreds of thousands of IoT devices is starting to become cost efficient. Strategically and logically placed sensors across a store can detect and transmit various types of data over wired or wireless connections. All this valuable data from the IoT devices is typically sent to a gateway device installed in-store, which then transmits this aggregated data to a server or on to the cloud. This data is then queried by the relevant business application tool to analyze the structured information to eventually generate insights for further action.

Most common applications of IoT devices in retail, connected over wireless network or Bluetooth can be categorized in 3 high level buckets and they are interlinked as shown below (see Fig. 1).

1. Customer facing experiences
2. Operational Excellence
3. Lifecycle management

Fig. 1. A model to see how areas of physical stores are prime for AIoT deployment and how they are interrelated

A. Customer Facing Experiences:

Customer Experiences is all about driving great omnichannel experiences for customers. New age customers are increasingly leaning towards touchless experiences and want to be quickly in and out of the stores. (see Fig. 2). Some examples of how AIoT can help drive a seamless and quick shopping process are:

1. Personalized Experiences through app and online
   - Use ML based recommendations driven through data to suggest products, prices, and promotions to customers in the app, online or in store.
2. Cashier less checkouts (Scan n Go)
   - This has a huge life saver during pandemic. Retailers have rushed to install self-checkouts and Scan n Go experiences. Scan n Go through Retailers app can be a super low-cost way driver cashier less checkouts. E.g., Walmart+ Scan n Go, Walmart+ Curb side Returns.
3. Vision based product search
   - Use the power of AI/ML and trained models to search for products in the app. Once the product is found give options to try on using AR based solutions.
4. Streamlined In-Store navigation and heat maps
   - Make it easier for customers to locate product. Use IoT to show AR based directions in the store to the product location. Leading to quicker navigation, less staff interactions and increased purchase rates thus providing customers with a digitized shopping experience of physical products.
5. Automatic Call center/Support
   - During holiday and peak shopping periods use AI/ML based solutions can take off load from Store associates and enable natural interactions with virtual agents and transfer calls to a real agent only when truly needed.

Fig. 2. What is the New-Age shopper expecting from Smart Retail Stores

B. Operational Excellence:

Retailers work on thin margins, and in a hyper competitive labor market while dealing with disruptive supply chain issues and seemingly uncontrollable shrinkage. AIoT can help with driving productive, happier store staff, and efficient backroom operations. Some examples of how Retailers can drive operational excellence and how impactful it is (see Fig. 3):

1. Alarms and Notifications:
   - Measuring temperature, humidity, and lighting in specific areas of the stores can help with reducing frozen product and produce wastage.
2. Inventory Management
   - Pandemic has shown how important inventory management is. Although some supply chain issues can be out of retailers control AI can play a huge part in optimizing and allow Retailers to know what's needed in what quantities at what time and what the cost is harnessing the power of computer vision systems, they can deploy object detection software to track inventory and send notifications in the backroom to replenish product on shelf.
3. Improving business operations
   - Security sensors gather information related to door armed/disarmed and help in communicating and monitoring and/or controlling other equipment such as emergency lighting, store security alarm system, HVAC systems, etc.
   - Smart equipment, including energy equipment management, detects information related to energy consumption; system availability, utilization, and performance during occupied, partially occupied, and unoccupied hours and during an emergency like situation and transmits the data to the gateway for further processing and analysis, as explained above
4. Data Analysis on the Edge
   - As the IoT devices collect huge amounts of data, processing this data in real time could be a challenge. However, using AI and ML trained models you can deploy models on the edge devices and detect fraud transactions real time. Make decisions on customer's propensity to buy product, and track customer lifecycle in app and store and suggest promotions and offers real time through the app.

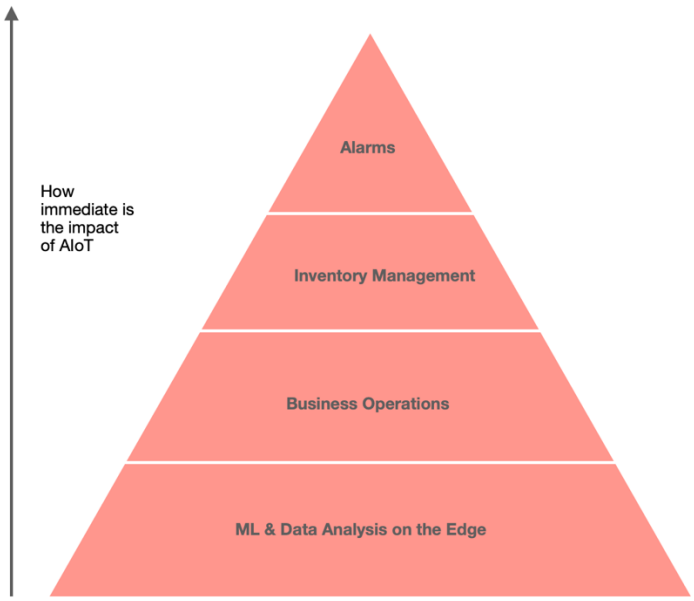

Fig. 3. What are the areas to deploy AIoT in Operational Excellence.

V. Low cost AIoT Opportunity

Showing accurate and competitive pricing is by far the biggest opportunity for Retailers to drive sales. Agile pricing or dynamic pricing is changing pricing on the flight due to the changing market conditions A few examples would be to incentivize products to drive sales, capitalize on popular seasonal items to drive demand, surge pricing think of Uber or marking down end of life. Historically changing pricing is a manual, error prone and time-consuming process. Using IoT based ESLs or low-cost mobile phones as ESLs can drive speed, accuracy, flexibility and give huge ROIs. Dynamic pricing benefits and increasing labor costs will drive the adoption of ESLs in the market, which is projected to reach USD $2.4 billion by 2027. [2]

Electronic shelf labels are the next generation of in-store signage. [9,11] ESLs are devices that use electronic ink displays to display retail prices, product information, and other information. [3] They are a viable alternative or supplement to the traditional paper price tags used in many stores today. ESLs can be easily updated by wirelessly transmitting new data, which can include promotions, inventory levels, and special offers, among other things.

Electronic shelf labeling systems allow retailers to update prices and other information instantly, without having to print new labels or manually attach them to shelves. The system is automated, which means it doesn't require a lot of time or labor on the part of store staff. And because they can be automatically updated from a centralized system, ESLs eliminate human error when it comes to pricing items and ensuring customers are charged correctly at checkout.

Electronic Shelf Labels in a retail environment is not a novel concept. The Smart Labels are an application of Internet of Things in the Retail space. On the other hand, there is one innovation which is ubiquitous, highly customizable, has a

well-established manufacturing pipeline, and is getting cheaper every year - the smart phone. Smart Phones are highly customizable because, they have this asset called the display screen which can be adapted to show exactly what you want using mobile phone applications or Apps. Smart Phones have internet connectivity, are extremely customizable using apps, can communicate with each other through Bluetooth during network connectivity issues and are available at a very conducive pricing by many manufacturers. [10] Smart phones have very well-established manufacturing and distribution pipelines.

Fig. 4. Mobile devices as ESL displaying content and pricing

The major players in the existing ESL market are Pricer, Displaydata Limited, SES-imagotag, E-ink holdings, Altieer Corporation, Clearink Display, Panasonic Corporation, Samsung Electro-Mechanics and others. [2] The type of screens used for display are usually LCD, E-paper or a screen with gull-graphic E-paper. With display sizes mostly ranging from 3inch to 10inch screens. However, a lot of the existing ESLs are still not IoT enabled and there is a huge opportunity to combine IoT capabilities with these ESLs and make them smarter, connected to cloud and real-time update ready.

Benefits of using mobile phones as ESLs are:

1. ESLs are generally cost effective and less time-consuming alternative to paper-based labels.
2. Easy availability of n-1 or n-2 generation devices which are significantly lower in cost. Retailers with low margins can use their older inventory as ESLs with reduced investment.
3. Store associate learning curve of device setup would be not as steep as setting up a new hardware in the store.
4. Mobile phones can connect already existing access points in the stores and do not need an overhaul of the in-store WIFI setup.
5. One of the major reasons retailers stay away from ESLs is the time it takes to update content and pricing. With Wireless connection these mobile phones would a decent connection to download Pricing data and basic content that is tied to each product.
6. ESLs drive customer engagement. With Mobile phones which are interactable, customers can navigate content and explore features of a product. This specifically applies to products which have content associated with them which helps them make purchase decision like TVs, size, colors, specification comparison.

An example of where the mobile phones as ESLs are successful is Apple Retail and Apple's Channel Partner stores. Apple has deployed multiple iPhones in their Retail Stores as Demo devices. These devices function as ESL and demo devices both. These devices run a home-grown pricing app which helps customers learn and experience the features of the device and helps customers make purchase decision my giving them pricing options, comparison options and more. The same idea of using mobile devices can be adopted by other retailers for electronic devices and can easily be deployed at scale.

Here we propose an application model which can be used to on low-cost devices and use them as a powerful AIoT devices: Taking the example of a shelf table displaying iPhone that are being sold. When setting up the mobile based ESL initially we tie the device to a catalog id and a SKU Id. This SKU id uniquely identifies the item against which the ESL is displayed. High level e.g., of this would be Catalog = iPhone, SKU Id = iPhone 8, SKU Id = iPhone 9, SKU Id = iPhone 10 etc. The only setup that's needed initially is store associate selecting the Catalog and SKU id that needs to be displayed. This information can then be relayed back to the server which can push the right set of content + pricing data for that specific SKU to that device.

In addition to the proposed design to track the ESLs and update them with the right pricing, a simple AI/ML model can be deployed on the Cloud with Notification server that can track for anomalies in pricing data on the devices and send information back to the devices in the store to auto correct. For e.g., it is common for devices to go out of sync with pricing in the stores or show incorrect pricing. As these ESL devices ping the notification server or a cloud server with telemetry data, an AI model can track the incoming data and using simple anomaly detection algorithm one can identify which devices are potentially out of sync on pricing and take corrective actions. While for the current experiment we relied on a simple hardcoded way to compare expected price with actual price and identify the incorrect ESL with price, deploying a trained ML model should be straight forward.
The detection and corrective signals can be sent over to the device with also a list of devices which have the right pricing. The ESL device can then take corrective actions to quickly fix the pricing data to maintain pricing consistency.

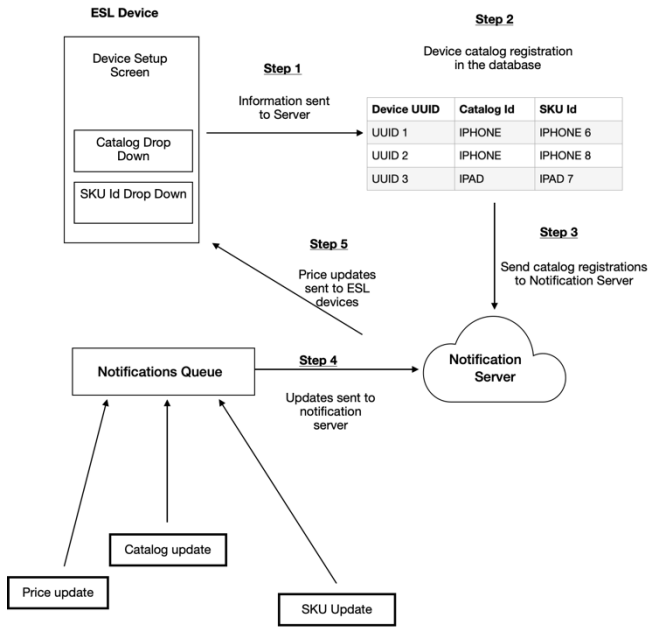

Fig. 5. Abstract system design to track ESL UUID to Catalog Id and SKU Id

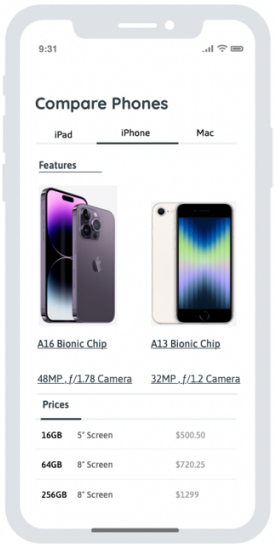

Fig. 6. Sample app to show price comparison

VI. Conclusion – AIoT is the future of Retail

It is not a choice, but a requirement for Retailers to embrace AIoT. The competitive edge lies with businesses who adjust, adapt and efficiently implement the smartest technology available today. The reason why it is so important for most of the Retailers to embrace and evolve with AIoT is that it not only gives them the insights into understanding the who, what, when, where, how much, how often of which product do the customers want, a treasure trove in itself, but also provides them with the cost-cutting advantage to translate the savings from smart and efficient operations into providing customers with competitive prices along with a rich experience in a digitally improved store

Emerging AIoT technologies are poised to reinvent the in-store retail world by streamlining operations and redefining the customer experience. From deeper visibility into supply chains and inventory management, to more efficient deployment of smaller in-store employee teams, retail operations are being transformed. The customer and the small+ large scale businesses are the ultimate beneficiary of this revolution in retail technology.

Finally, ESLs are viable low-cost way to deploy dynamic pricing in the Retail stores to solve one of the biggest pain-point of inaccurate pricing and missed sale opportunities.

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