Breaking
The Big Store Barrier
in Automated Grocery

How going from a 3,000 square foot store to a 40,000 square foot supermarket is now possible.

trigo™

Online grocery is great, but merging digital with the physical is better

The idea of standing in line at a grocery store is something that most people loathe and dread, even without a global pandemic around. Fortunately, over the past 20 years, technology has freed us from standing in line at many customer-facing places -ATMs instead of banks, self-check-in kiosks at airports, or renewing one's driver's license online. However, despite game-changing innovation in the last couple of years, grocery stores and standing in line remain intricately linked in most people's minds.

While 2020 saw a significant rise in groceries being ordered online due to Covid-19, the business model remains unprofitable to retailers. A study by Bain estimates that companies that use staff to fulfill online orders and deliver them lose 10-15% on every order, depending on delivery fees.

Furthermore, a McKinsey survey indicates that although consumers feel very satisfied with online shopping, they view it as a temporary measure and plan to return to physical stores once possible. The survey covers five European countries, and the only country where consumers expect to increase their online grocery shopping is in the United Kingdom, with a net intent of +5 percent. McKinsey foresees a shake-up among grocery players as they battle for consumer loyalty. For retailers, that means that now is a critical time to invest in retaining their newly gained customers.

One potential investment for retail is to increase the automation level within their checkout operations to combine the ease of online with the tactile experience of in-store purchasing.

A recent survey by CapGemini found that the introduction of automated solutions appeals to the consumer, with 66% believing it can solve challenges such as long checkout lines. Additionally, 46% of consumers are willing to shift their online purchase from a wholly online retailer to a retailer with stores that use automation technology. Finally, 59% of consumers who have previously visited stores with automation would shift purchases to a store with automation technologies if they had a positive experience. The survey concludes by stating "automation offers clear benefits to both consumers and retailers. By solving the challenges they encounter and creating a positive experience, it can entice shoppers back into stores, thus staving off competition from digital natives while reducing costs and making employees more productive."

Even the 300 pound gorilla in the store is humbled

While the prospect of eliminating checkout lines via technological innovation is tempting for retailers, the associated challenges are not to be underestimated, even for a business with close to unlimited resources such as Amazon.

Although the online behemoth has come to dominate almost every retail operation type, groceries appear to be a hard nut to crack. In 2018 Amazon announced that by 2021 it would operate 3,000 checkout-free Amazon

Go stores. The current count is less than 30, **a clear indication of the challenges involved in combining the seamlessness of online with the physical experience of purchasing food**, despite consumer interest.

For grocery chain operators who see themselves as competitors to Amazon - and there are many - the challenges are even more daunting. Whereas Amazon Go stores are tailored to maximize the benefits of Amazon technology, other retailers don't have that luxury. For example, all Amazon Go goods are pre-packed or sold per unit for fruit and vegetables, and the aisles are wider, making it easier for Amazon's system to capture the data it needs. This is a substantial investment for a solution tailored just to a small store (3,000 square feet), with Amazon controlling every step of the value chain - something other retailers cannot countenance.

Hence, installing an Amazon Go-style solution in a 40,000 square foot store - the average size of a grocery store in the US - would require a significant capital investment and a complete remodeling of the store. **That's what's called 'the big store barrier' in computer vision-based automation of grocery stores.**

When the physical footprint of a store doubles from 1000 square feet to 10,000 square feet, the number of cameras needed to cover the store grows linearly from 100 to 1,000. However, the data-processing algorithmic complexity is much larger and has to then resolve many more scenarios – as the number of potential interactions items increase dramatically with store size. For example, if a shopper picks up a loaf of bread in one section of the store and then moves on to the dairy section; the system needs to retain the information of the items in their shopping cart so that the customer does not have to sign in to each section as if it was a seperate store. Hence, a scalable solution needs to be able to seamlessly handle the 10X increase in data that comes with the 2X increase of square meterage.

Bridging the
Big Store Barrier

Consequently, retailers need a solution that can be implemented across their operations regardless of each store's current size, without the need for a complete remodeling of the locations. Finally, the solution also needs to be flexible enough should the store's footprint change in the future.

Trigo approaches this challenge by leveraging artificial intelligence computer vision in its frictionless checkout retail solution. Trigo's name derives from the triangulation needed to pinpoint an object's exact location in a three-dimensional space. Trigo transforms the data provided by multiple cameras into a 3D map where each pixel captured by a camera represents a coordinate in a three-dimensional geometric space. The coordinates are then triangulated with data from additional cameras to generate the exact location of the object, allowing the system to track it. As objects move from the shelf into the customers' baskets, shoppers won't notice anything and won't be required to perform any additional action.

To capture the huge number of images needed in a grocery store, Trigo deploys hundreds of off-the-shelf cameras placed in the ceiling to achieve complete coverage of the store. The images captured by each individual camera are fused in the back-end into a map covering the entire store. Hence, if the customer's purchases are not visible from one camera, another one fills in the blanks. Each camera takes dozens of photos every second, so even though a customer might be in a hurry and walks quickly through the store, to the system, the shopper is no faster than your average snail.

The speed and efficiency of the data generated by the cameras combined with the smart and cost-effective software processes taking place in the background are critical, because if customers cannot walk around the store as they desire or if they need to move an item from the shelf to basket multiple times for the system to recognize the action, the solution drastically reduces in efficiency and value since one is effectively switching the checkout queue with another time-consuming behavior.

Although Trigo relies on a more significant number of cameras than its competitors, the cost of off-the-shelf hardware is offset by the higher level of accuracy of the system, enabling it to operate in narrow aisles full of busy shoppers. More importantly, while it might be possible for competitors to add cameras, there is no quick and easy solution for catching up to Trigo's technological advantage.

Looks and feels easy on the outside. But behind the scenes there's major computing.

The ease at which the consumer interacts with an effective frictionless retail solution- the only "friction" required is to scan one's phone when entering the store- is contrasted by the complexity of the solution's back end where the data is crunched.

Trigo utilizes its patented proprietary neural network to track objects in the store and monitor the interactions between them. The company's core technology focuses on geometrical computer vision and the challenge of accurate real-time monitoring and interpretation of the vast amount of data generated each second in a dynamic environment such as a grocery store. The solution needs to generate a holistic understanding of the actions being undertaken in the store and how they relate to each other. The system needs to understand the action of each individual shopper, it is not enough to register that an item was transferred from a shelf into the shopper's basket. The system needs to understand which customer, what item, and at what time the transfer occurred. For example, if a customer circles back to an aisle because they only took one carton of milk instead of the two they intended, the action needs to be correctly assigned and billed to said customer.

Achieving a high level of accuracy is critical from both the customers' as well as the retailers' perspective, since no one wants to be charged for items they did not purchase, and the retailer wants to be sure that customers do not leave the stores with more goods than they paid for. Such occurrences would undermine both sides' trust in the system and reduce the customers incentive to shop at such a store, even if the shopping experience itself is generally pleasant.

It is important to note that although the solution does track each customer's movement and interaction in the store, Trigo's privacy-by-design feature does not identify customers and operates in accordance with the data privacy regulations where it operates. The only information sent to the retailer is a randomized number so that the shopper receives the correct receipt.

Living on the edge (cases)

Especially challenging and rare instances, known as edge cases, include events where a combination of different factors either reduces the line of sight of multiple cameras or when the customer picks up an item that is smaller than their hand, like a stick of gum, for example. While these instances might occur rarely, getting them right - as was noted above - is critical.

Edge cases are by nature rare: the average visitor to a store might only experience a specific event once in 10 years. However, if a customer visits their local store 50 times per year and there are 500 additional daily shoppers at the store, from Trigo's point of view, the data generated represents 10 years of shopping activity and so the rare becomes common due to the number of stores its solution is operating.

Trigo leverages the higher frequency of events to generate a stream of data analyzed by the neural network. Therefore, although from a shopper's point of view the edge case is rare, Trigo is ready for it by having seen it numerous times in the millions of images processed each day, thereby solving edge cases at an accelerated pace.

In addition to learning on the job by analyzing actual scenarios from stores, Trigo also relies on a data set of millions of 2D photos of objects to train its system.

(Artificial) mind over matter

The mobility industry relies on artificial intelligence computer vision to develop object recognition systems for driver assist and autonomous cars. However, the development process has resulted in the establishment of large and expensive back-end offices, where vast numbers of employees manually tag an object in a frame to ensure the AI has identified it correctly.

There is no need for a vast human back-office tagging function with Trigo's solution due to the accuracy of automatically determining what product shoppers are putting in their basket. The system is so precise that only in exceedingly rare edge cases are the images reviewed by a human before the result is added to the system database. Keeping in mind that the average U.S. grocery store stocks between 30,000 to 40,000 stock-keeping units on the shelves at any given time, the need for an effective neural network is paramount.

An additional benefit of a highly accurate log of a store's inventory is that the information can, should the retailer choose so, be leveraged to improve the store's operations. For example, should an employee place an item on the wrong shelf due to distraction, or forget to put ice-cream in the freezer, Trigo can alert the store operator and a loss can be prevented. The system can also reduce the time spent restocking the shelves by generating an automatic report on what items are missing or will shortly be missing from the shelves because they are being picked up by shoppers. Currently this time consuming and not particularly accurate process is conducted by an employee who walks around the store with pen and paper writing down what needs to be brought up from the storage area. By utilizing Trigo's solution the employee can focus on providing service to the shoppers instead of menial tasks.

Trigo's neural networks' high level of accuracy and efficacy allows the company to address two of the most pressing challenges faced by retailers looking to implement checkout-free solutions: scale and size. Due to the versatility of Trigo's solution it can be deployed no matter the number of stores operated or the size of the individual stores.

When considering that the number of cameras needed increases linearly with the store's size, if 100 cameras are required to cover a 3,000 square foot store, it would require 200 cameras to cover a 6,000 square foot store. However, with the number of cameras growing linearly, so does the amount of data they generate, with a refresh rate of dozens of times per second (a high-definition TV refreshes 60 times per second). The system generates one petabyte, or, depending on the size of the store, between 500 million to 1 billion photos per day in an average-size supermarket, further highlighting the need for a powerful AI to ensure real time tracking of items in the store.

The only constant in life is change

In addition to a steady flow of customers of all sizes and shapes, the packing of goods are ever-changing as well, with packaging changing seasonally and during promotional campaigns. For example, in 2013 Coca Cola in the United Kingdom launched a campaign where first names replaced the company's logo on bottles and cans. The following year Nutella followed suit. While a commercial success for the companies, this seemingly small change represents a tremendous challenge for computer vision software because the new logos represent a new and unclassified product for the neural net to get its head around.

The Coca Cola and Nutella campaigns highlight the advantage of having a data driven and highly accurate system that can utilize a high degree of automated learning when it comes to analysing the image data generated, either from customers' actions or new items added to the store's inventory. The advantages of a dynamic and self-learning system are not limited to special events but can be utilized during normal operations as well. For example, perhaps the store received a shipment of goods that was not supposed to arrive on the said week. Nevertheless, the items need to be placed on the shelves as well as be added to Trigo's solution so that the shoppers can be charged when adding the items to their shopping cart. For retailers looking for a frictionless solution, automated learning is critical, particularly when considering scaling up the deployment to a large number of locations.

Trigo is the only commercially available platform dedicated to tackling both aspects of scaling: store size and the number of stores. On the physical end of scaling, it is essential to note Trigo's solution's elasticity compared to Amazon's Go system, which has only deployed its solution in purpose-built stores designed to interact with their technology.

For example, each aisle's width in an Amazon Go store is wider than in an average supermarket, which means less shelf space and fewer products to sell. Furthermore, the primary purpose of the current iteration of the Amazon Go store is not to make a profit, it is to train Amazon's AI. Combined, all of these limitations make it difficult for a retailer to implement Amazon's solution since it would involve both a high initial cost and a lower profit margin moving forward.

Moore's Law vs. Huang's Law

Moore's Law, named after famed Intel CEO and Co-Founder Gordon Moore, stipulates that the number of transistors on a chip doubles roughly every two years. It also meant that those chips' performance—and the computers they powered—increased by a substantial amount on approximately the exact timetable.

Huang's Law, after Nvidia CEO and co-founder Jensen Huang, predicts that the performance of the Graphics Processing Unit or GPU, dedicated to processing the pixels in an image to decode it, will double every two years. With their specialization in image processing, GPUs provide the computational power for the neural networks underpinning artificial intelligence computer vision.

The implications of Huang's Law for Trigo and its customers are tremendous. For example, suppose a user pays $1,000 for the servers needed to process the images for a specific store, with the computational power of these servers doubling every 18-24 months, the client's costs will halve since fewer servers can handle the same amount of data generated from the store. This significantly reduces the back-end data processing costs, which is currently the main expense in Trigo's solution since it relies on off-the-shelf cameras and sensors for image capturing.

With the computation- or rocket ship as Trigo refers to its proprietary AI image processing solution dedicated to smart and effective computation- being the most expensive part of the operation, it is the main focus of Trigo's practical efforts both in speed and cost-effectiveness.

Currently, a significant portion of the computation occurs in the cloud, reducing the need for many servers at each store. This brings down both the solution's physical footprint and possible interference with the customers' shopping experience by generating unwanted noise.

The emergence of online retail has fundamentally changed the way consumers go about the business. Despite the convenience of click and delivery, people still prefer the tactile experience of touching and smelling their groceries.

Hoverver, a number of recent studies from international consulting firms such as McKinsey and CapGemini, indicate a positive attitude among consumers towards solutions that integrate the seamless experience of online shopping with a brick and mortar store, especially ones that reduce time spent standing in line.

Retailers looking to keep up with the demands of their clients need to ask themselves if there is a cost-effective solution that covers their current need and then can scale up regardless of the number of stores and the size of the stores.

World wide presence

Israel | USA | UK
Germany | Netherlands

www.trigo.tech

Trigo tech-powers grocery stores with market leading touch-free checkout and digitized operations.

AI-driven and fully automated, our proven solution layers digital commerce capabilities onto existing spaces with zero downtime to business.

trigo™