

Automated Visualization of Food in Canteens

Improve efficiency and customer experience with fully automated self-service checkout solutions powered by computer vision.

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During peak times, it is common to see queues building up to a point where it takes much longer to pay for the food you are buying than it took to choose the food you want to eat in the first place. This is not the optimum customer experience, especially when the choice of restaurants are increasing and lunch breaks are shrinking due to work priorities.

Technologies such as AI, Cloud and IoT are no stranger to the restaurant segment. There is an opportunity to drastically improve the customer's experience by reducing the queueing times and providing a faster checkout service. Neurolabs has conducted several studies in various canteen sites across Romania and the UK. These studies concluded that, on average, it takes about 46 seconds to scan three to four items an individual has picked out for lunch.

This paper discusses the right hardware and software combination to enable a faster, easy-to-use solution that helps move customers through tills quicker. The most recent field tests completed by Neurolabs have shown, on average, the system takes less than two seconds to scan four items on the tray with an accuracy of 98 percent. By increasing the velocity at the till, the length of the average queue is significantly reduced, providing a more favorable experience to customers.

Canteens

There is an abundance of canteens across businesses, educational establishments, healthcare services and in general across the hospitality sector. In a busy working day, customers expect nutritional food with quick service that maximizes their time to enjoy the food. Catering services will need to focus on moving customers through the food selection and payment process as fast as possible by making the experience easier.

Technology has played a significant role in creating the right ambience, providing contextual information through signage and integrating it all together with the point of sale (POS). However, it doesn't address the nutritional aspects of the items or the speed of checkout for the customers who are in a hurry in the self-service category.

Self-service Customer Experience

In general, it is said that one of the least favoured restaurant experiences is the long time it takes to receive and settle the bill after the customer has finished their meal. It has been shown that a poor bill payment experience negatively impacts the reputation of the restaurant and the perception of the experience the customer had at the restaurant before the billing stage.¹ This is amplified in a self-service environment, when queueing up for even a couple of minutes to make a payment results in frustration.

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Figure 1. Ideal customer journey

In a self-service environment, especially where warm food is available, not everything can be contained and tagged with a barcode. Items picked up could be priced on either weight or volume. In certain cases, there are meal deals that consist of food from specific categories at a fixed price. Today's POS systems are smart, and if the SKUs are entered accurately, the right total will be computed across all types of pricing systems introduced by the canteen.

The ideal experience for the customer would be to be billed automatically at the checkout by analysing what's on the plate or tray in a very short period. This would require a system that can identify everything on the tray, including the weight and volume of certain items. The system would be complete if it could also show the nutrients included in the meal and then automatically add the loyalty points and provide a method for customers to leave feedback—for example, by gesturing thumbs up or down.

While the customer experience is vastly improved, this also increases the number of customers that can be served. In addition to improving speed and efficiency, this eliminates the theft that can occur in self-service environments when individuals scan lower-priced items for higher-value items. The checkout staff can be significantly reduced or made available to focus on higher value-added tasks such as ensuring customer satisfaction, being available to answer customer queries, keeping the canteen tidy and ensuring food is fresh and shelves are stocked.

Product Recognition

Computer vision using deep learning has emerged as one of the best methods for identifying products with high levels of accuracy. Training and inference are two key aspects of deep learning.

Training is the process of learning based on large quantities of data. Inference is the ability to infer results from the trained model when data (the same type of trained data) is presented.

Deep learning is focused on neural networks, which mimics the structure and functioning of the human brain. Large quantities of labeled data are passed into the network, and each new piece of training data helps increase the accuracy of the prediction. When the training process has been completed and the deep neural network (DNN) is making

predictions with enough accuracy, the model weights are then frozen and can be used for inference.

However, in relation to the food industry, new cuisines are prepared regularly and therefore it is not feasible to produce large quantities of data that will be enough to train the DNN models. This requires an alternative method of creating labeled data so that food can be identified accurately during checkout.

Synthetic Data

The majority of products, especially food items, never look the same. They come in various colours, textures and shades. Generating synthetic data and combining it with real data does in fact make it possible to create an unlimited number of variations of training data. This is not only more scalable and faster, but it also reduces the effort of labelling the information, as well as reducing the costs.

Neurolabs is using a combination of real data and synthetic data to build more accurate AI models and then proving its effectiveness in end-to-end solutions. Synthetic data is created by generating advanced virtual 3D models of food items. Once the 3D model of a food item is created, Neurolabs can generate as much synthetic data as they need.

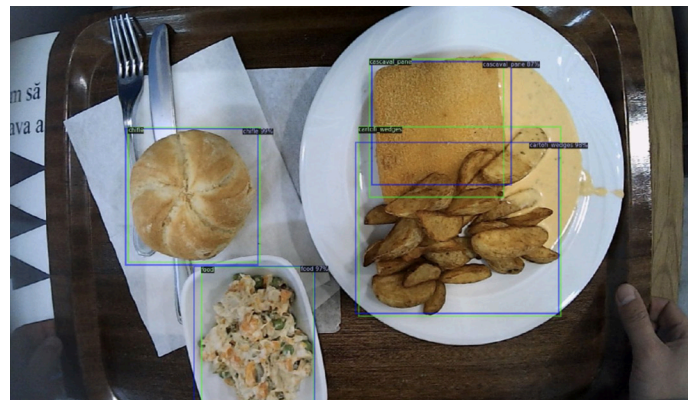


Figure 2. Product identity using models trained with real and synthetic data

Figure 2 shows the accurate identification of multiple items on a tray. Neurolabs has been able to demonstrate the accuracy of product identification based on their current deployment in several business canteens.

The canteen used by Neurolabs has over 70 product classes. The table below shows the improvement of product identification accuracy:

| REAL DATA | SYNTHETIC DATA | ACCURACY (MAP) |
|-------------|----------------|----------------|
| 2900 images | X | 71% |
| 0 images | ✓ | 73% |
| 300 images | ✓ | 78% |
| 2900 images | ✓ | 94% |

The increased accuracy is due to the Neurolabs software being able to generate 100,000 synthetic images in two hours. This allows the data to be created using various product orientations and lighting conditions, including partially covered products and upside-down items. By employing this methodology, Neurolabs has been able to provide above 98 percent accuracy and the ability to identify products within two seconds in their field tests.

Self-service Kiosk

Earlier this year, Advantech introduced a fully automated self-service system for canteens. The system allows the customer to place a tray of food on the kiosk, which automatically scans all the products simultaneously using the Neurolabs AI models. The scanned product details are pushed to the POS application, which then automatically shows the food items along with the amount the individual needs to pay. The customer can verify the information given, make the payment and then enjoy the meal.

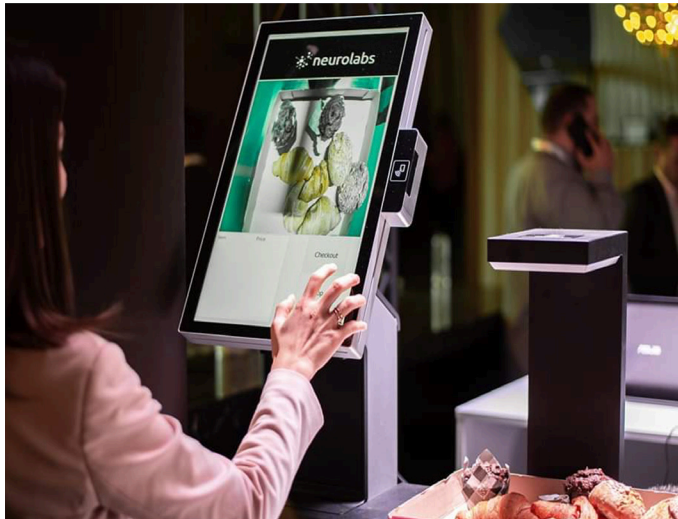


Figure 3. Self-service kiosk

Figure 3 shows how the entire system has been put together. Advantech’s UTK-752 self-service kiosk, consisting of a receipt printer and pin entry device, has been augmented to work with a high-definition camera.

The software includes Neurolabs product identification and the integration to the POS system. The kiosk is powered by Intel® Core™ processors. The platform offers a friction-free and completely autonomous checkout experience within three seconds, complete with payment approval.

The solution is deployed on premises, while the model training is done on the cloud and inferencing is completed either on the kiosk or the cloud depending on the volume of transactions. Having access to the cloud is particularly attractive as it allows for real-time centralisation of data across multiple kiosks and canteen sites.

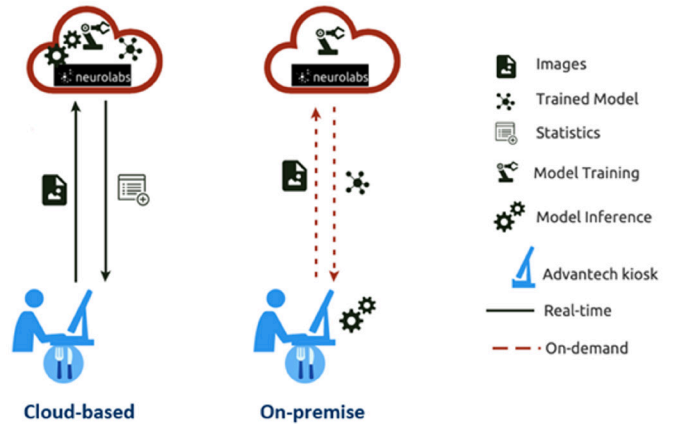


Figure 4. Deployment models

In order to accommodate for the unplanned introduction of new items in the menu, Neurolabs has developed a feature that allows new items to be automatically recognised after being “seen” as few as five times by the camera. This feature represents a temporary measure to deal with the introduction of new items before 3D models of the new items are available.

Future Direction of the Self-service Kiosk

Advantech is closely working with Neurolabs on the next generation kiosk to include Intel® RealSense™ cameras so that volumetric measurements could be made to enable new use cases and augment the self-checkout technology.

One of the new use cases under consideration is the calculation of hospital patients’ nutrient consumption. By analysing before and after snapshots of the patient’s plate, the system will be able to monitor the nutrients consumed by the hospital patients. This is a manual process in hospitals today and offers the opportunity to determine nutrient consumption more accurately and relieve hospital staff to do more valuable tasks.

As canteens start to get busy and the number of products/ food items increase, in order to suitably support the volume of transactions and reduce any latencies, Neurolabs is opting to use an in-store edge server with higher inferencing speed and lower latency by optimising their inference models on Intel® Distribution of OpenVINO™ toolkit.

Conclusion

Fully automated self-checkout canteen solutions bring several benefits to the canteen operator and its customers. The operators can increase the number of customers served, reduce checkout staff and eliminate theft at checkout. Staff can be refocused to more important tasks that would increase customer satisfaction. Similarly, customers can check out much faster as the food items are identified simultaneously instead of having to scan each item one at a time. Depending on the number of checkout systems in the canteen, the queueing time will be drastically reduced and provide a more pleasurable experience to customers.

Learn More

You may find the following resources useful:

- [Advantech RRK – Self Service Kiosk Technology](#)
- [Advantech iRetail](#)
- [Intel vPro® Technology](#)
- [Intel® RealSense™ cameras](#)

Solution Provided By:



¹Laurette Dube-Rioux, Bernd H. Schmitt, and France Leclerc (1989), "Consumers' Reactions to Waiting: When Delays Affect the Perception of Service Quality", in NA - Advances in Consumer Research Volume 16, eds. Thomas K. Srull, Provo, UT: Association for Consumer Research, Pages: 59-63

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