Smart Showcase That Contributes to Labor-Saving of Store Work

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ABSTRACT

Convenience stores in Japan are struggling with high labor cost due to staff shortages, and they need to save labor on in-store work. To address this problem, Fuji Electric engages in the research and development of a labor-saving smart showcase that helps automate goods management, one of many in-store tasks at convenience stores. This smart showcase automatically recognizes the name and quantity of products in it. It combines a camera to identify product names and panel sensors to detect the quantity.

1. Introduction

The use of Internet of things (IoT) is accelerating, and this includes its use in the retail industry. In the United States, some grocery stores have already begun to use cameras and sensors to detect the movement of shoppers and goods. Shoppers complete payment by simply putting goods in their shopping bag and passing through a gate. This store frees customers from the inconvenience of waiting for a cashier.

In China, unattended container-type convenience stores and unattended supermarkets operated by online mail order companies have been established with the aim of reducing operating costs. In these types of unattended stores, customers can enter locked stores after authenticating themselves at an entrance reader with their ID registered with a Chinese electronic payment service. When items to be purchased are placed in the checkout space, electronic payment of the total amount is made based on the electric tag attached to the product.

Convenience stores in Japan are also seeking ways to achieve labor savings to remedy labor shortages and high cost of labors However, it is difficult to move to unattended stores immediately due to the variety of services offered and the strong character of the infrastructure. Therefore, labor savings are being advanced through various labor-related improvements on the sales floor of the shop. This paper describes Fuji Electric's efforts on smart showcases that contribute to labor savings.

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2. Challenges Facing Convenience Stores in Japan and Use of Fuji Electric Smart Showcases

Japan is currently facing an aging population and labor shortage. This trend has affected many industries including the retail industry and it is expected that this will continue to cause labor expenses to rise. Furthermore, convenience stores have been adding new services to increase sales, but that has increased the type and amount of works which has become burdensome to store clerks. Therefore, emphasis is being placed on reducing labor costs while achieving labor savings that can create the capacity to offer new services.

In order to meet the labor-saving needs at convenience stores in Japan, Fuji Electric has been developing a smart showcase as one of the components for realizing the short term goal of achieving labor savings on the sales floor and the medium-to-long term goal of achieving store automation and transition to unattended stores.

In order to prepare the sales floor, it is not enough to simply put products on display. There are many burdensome works involved, such as moving products located at the back of showcases forward after products in front are sold, changing arrangements and layouts, replenishing stock and replacing soon-to-be expired products with new ones. The smart showcase contributes to labor savings by reducing shop work related to preparing the sales floor.

3. Features of the Smart Showcase

The smart showcase is characterized by its ability to automatically detect the type, quantity and status of products placed on the shelves of the showcase to man-

age the products actually displayed in the showcase.

This product management contributes to labor-saving. For example, when replenishing products, clerks can check what products and how many of them need to be replenished from anywhere in the store, and this helps eliminate carrying out unnecessary products to the sales floor and decreases the number of trips to and from the stockroom. Furthermore, this feature help improve the efficiency of the sales floor because clerks can check the state of showcases and find the location of products that need to be moved forward without walking around the sales floor.

In the smart showcase, it is assumed that identical products are arranged depthwise, and on the basis of this, the showcase identifies the name and position of frontmost products with the product name identification controller and detects how many products are placed in depthwise with the panel sensor controller.

As shown in Fig. 1, the smart showcase system mainly consists of the following devices:

(1) Product name identification controller

It identifies frontmost items using images taken with a camera.

(2) Panel sensor controller

It detects how many products are on the shelves of the showcase.

(3) Management controller

It centrally manages data received from the product name identification controller and the panel sensor controllers to notify the in-store tablets of the types, quantity and status of products.

(4) In-store tablet

It displays information to help the clerk check the showcase's product display condition.

The point of sales (POS) system has been introduced as a system for managing products in convenience stores and is characterized by its ability to manage the quantity of stock for the entire store. Therefore, the POS system alone cannot determine whether products are on a showcase or in the stockroom. In contrast to this, the smart showcase makes it possible to know what products are on the showcase, thus enabling clerks to manage the number of products actually placed on the sale floor.

In this regard, the Ministry of Economy, Trade and Industry has formulated the "Declaration of Plan to Introduce 100 Billion Electronic Tags for Products in Convenience Stores Formulated"[1] as an initiative to attach electric tags to all products handled by convenience stores by 2025 in order to facilitate individual product management. Electric tags provide several advantages such as the ability to read multiple electric tags at once from a distance, write IDs to individually identify products and manage information such as expiration dates. The challenge is to reduce the cost of electric tags and the cost of attaching them.

On the other hand, smart showcase cameras and panel sensors can identify products and detect quantity without having to attach an electric tag to products. Furthermore, unlike electric tags, it can detect the exact position of products, and in this regard, we expect that the smart showcases will be used in combination with electric tags in the future to enhance the identifying function for product location.

4. Product Identification and Detection Technology

4.1 Product name identification controller

The product name identification controller consists of a camera control component and product name identification component. The camera is connected via Gigabit Ethernet through a Power over Ethernet (PoE) hub. The PoE hub is used to supply power to the camera.

As shown in Fig. 2, the camera should be installed on the ceiling of a store with a height of approximately 2.5 m. A single camera is used to capture images of the entire product display for each individual showcase. For the product imaging system, we also considered mounting a camera to the ceiling of each shelf of the showcase to capture images directly above the products and mounting a camera at the foremost part

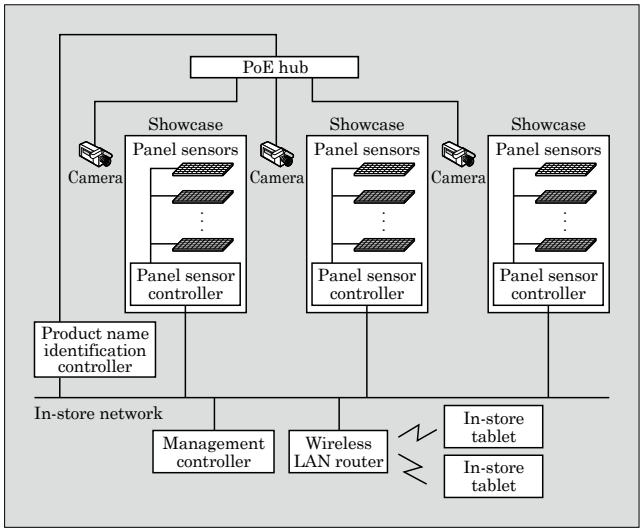

Fig.1 System configuration diagram

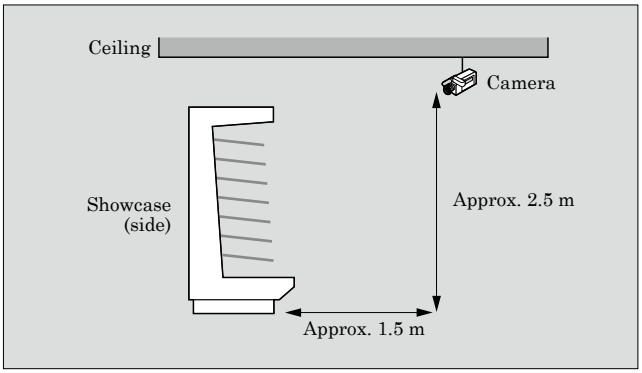

Fig.2 Relationship between the showcase and camera position

Fig.3 Showcase product image taken with the camera

of the shelves to capture images of the front of the products. However, we ended up adopting the method of capturing the images from the ceiling of the store for the following reasons:

(a) To prevent the camera from interfering with product display set-up and product purchasing
(b) To prevent reduction of the display space
(c) To reduce the number of cameras needed

A high-resolution (14 million megapixels) industrial-use camera is utilized to ensure that the images of each product are taken clearly. Figure 3 shows an actual image taken with the camera.

The product name identification controller identifies the product name ID and position of the frontmost products in the showcase using the images captured by the camera.

A "feature matching method" is used for identifying product names. This method uses the images of applicable products captured beforehand to register the product feature, which was extracted using machine learning, as matching data into the product name identification controller, and then matches against the feature of the images taken with the camera. In order to raise accuracy in identifying products, the matching data is prepared by capturing product images from various angles, because the camera will view products differently depending on how they are arranged and positioned in the showcase.

4.2 Panel sensor controller

The panel sensor controller detects the number of products by controlling the panel sensors. A panel sensor is integrated into each shelf of the showcase and the products are placed on the panel sensors.

The panel sensors utilize projected capacitive touch panel technology that arranges the transmitting electrodes and receiving electrodes as a matrix. When a product is placed on a panel sensor, the capacitance between the transmitting and receiving electrodes changes, and this enables the shape of the contact surface to be recognized by sensing changes in capacitance at each intersection of the matrix and then plotting it two-dimensionally.

Products handled by convenience stores use various container shapes and materials, and the way each product sensed by the panel sensors differs, thereby switching the quantity detection algorithm for each individual product.

For example, in the case of products such as plastic bottle and canned beverages, which are characterized by a stable contact surface shape and large dielectric constant, the contact surface shape can be detected clearly because the signal strength is strong and there are few differences between individual items. As an example, Figure 4(a) shows 22 actual plastic bottle beverages placed, and Fig. 4(b) shows the two-dimensional plotted image of the detection state of the 22 beverages on the panel sensors. For these types of products, the quantity of products is detected via template matching using pre-registered plotted patterns.

On the other hand, in the case of unstable shaped products such as rice balls, which are characterized by individually different bottom surface shapes and an easily deformable contact surface, the signal strength of the contact surface varies and discrepancies occur according to individual differences and how products are positioned on the shelf. This makes it difficult to detect the quantity of products using template matching. Figure 5(a) shows an extract of the individual-detection state of rice balls. These types of products are divided into valid and invalid detection regions by setting a threshold value for the signal strength [see Fig. 5(b)]. Small regions are removed as noise, and the quantity of products is detected based on areas of the effective region.

With these contrivances, by combining camera based product name identification and panel sensor based product quantity detection, we were able to achieve an identification accuracy of 94%, exceeding our original target of 80%, when identifying the prod-

(a) Plastic bottle beverage arrangement

(b) Detected image

Fig.4 Example of detecting 22 plastic bottle beverages

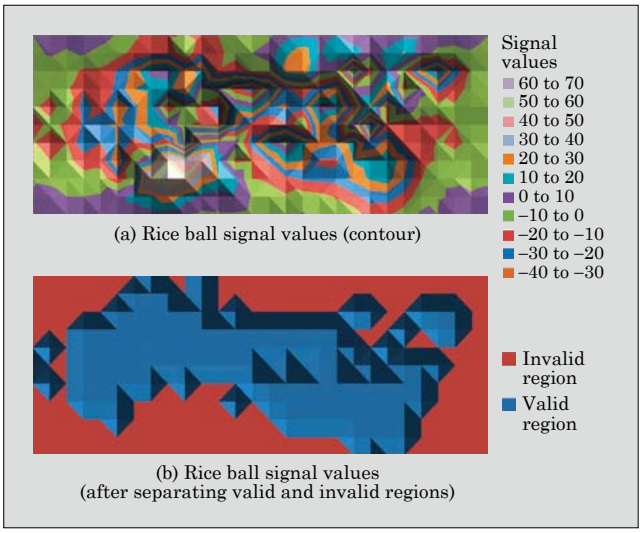

Fig.5 Detecting individual rice ball (excerpt)

uct names, quantity and status of 70 typical convenience store products, such as beverages and rice balls, that were placed on the showcase shelves.

5. Application Example

A prototype of the smart showcase was exhibited at the Supermarket Trade Show in February 2018. Figure 6 shows the prototype. Panel sensors were installed for the prototype on the third shelf from the top. A camera was not used due to circumstances at the exhibition hall, and thus the position and type of frontmost products were fixed. The prototype displayed a list of names, quantity and items requiring replenishment on the screen for 10 different types of products. A demonstration was provided in which the quantity and items requiring replenishment changed in real time as products were removed from the shelf. The smart showcase was very popular, especially for the fact that it did not require the use of electric tags.

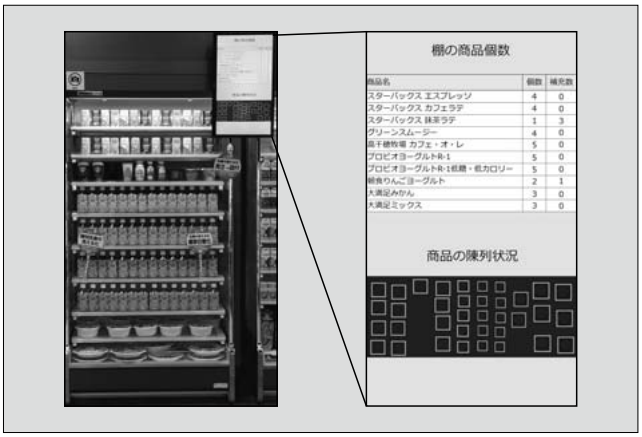

Fig.6 Smart showcase prototype

6. Postscript

This paper described a smart showcase that contributes to store labor savings. In the future, we plan to continue to expand the number of applicable products and improve the identification accuracy of product names, quantity and status.

The use of IoT has great potential in convenience store and supermarket applications because it achieves labor savings for the store and improves the convenience of customers. High-quality sensing technology is essential for utilizing IoT, and as such, we plan to continue developing sensing technology as we develop and release products and systems that provide high customer value.

References

(1) Ministry of Economy, Trade and Industry, “Declaration of Plan to Introduce 100 Billion Electronic Tags for Products in Convenience Stores Formulated: To solve social challenges lying in supply chains”. 2017-04-18. http://www.meti.go.jp/english/press/2017/0418_003.html, (accessed 2018-06-18).

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