

# RefrigeMeter: Automatic detect/display system for items in the refrigerator

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**Abstract.** People often have problems to leave foods in refrigerators too long time and spoil them. To solve this problem, we propose a simple interactive surface, "RefrigeMeter", which can automatically detect the positions of items placed in the refrigerator and informs users of their duration. The RefrigeMeter consists of LED arrays, a micro controller, and an acrylic board to cover these devices. First, the system detects positions where items placed on the shelf using LEDs as photo diodes. Second, the system calculates the duration while each item keeps its position. Third, the system activates the LEDs in different frequencies based on the duration of items on each LED. Thus, users can tell the status of items in refrigerator at a glance without any special operation.

**Keywords:** Refrigerator, LED array, sensor, display, ubicomp

## 1 Introduction

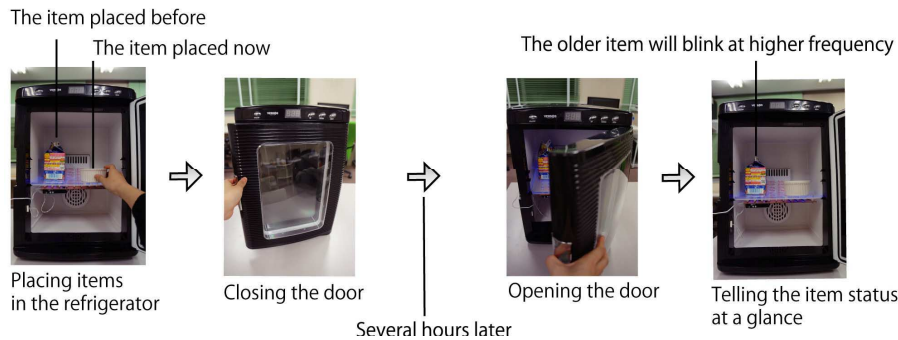
Many people would have experienced that they left foods in refrigerators so long that the foods spoiled. The causes of this situation lay in difficulty to check the status of items: users cannot check the timestamps - when the items are placed - and they often forget items that placed in the back of the refrigerator. Many research projects have been proposed, which try to solve this problem by attaching RFID tags on foods and registering them into database [1, 2]. However, users often have difficulty to use these systems in long term since most of them require users to register items manually. We therefore propose a novel system, "RefrigeMeter", which informs users of the status of items in a refrigerator visually without any special operation.

## 2 RefrigeMeter

The RefrigeMeter mainly consists of a detection component and a display component attached on a shelf of a refrigerator. Using the RefrigeMeter, users can obtain the status of items at a glance just by getting/putting the items as usual.

We applied light-emitting diodes (LEDs) as both detection/display components for simple and inexpensive configurations. That is, we treat LEDs as (1) photo diodes to detect the status of items and (2) lights to display the status. First, the system detects

positions of items using LEDs as photo diodes and calculates the duration in which each item keeps its position. Next, the system activates each LED in different frequencies based on the duration. When the duration becomes longer, the LEDs come to blink faster(Fig.1).



**Fig. 1.** The RefrigeMeter concept: when a user puts items in the refrigerator, the system presents the status of the items by activating the LEDs in different frequencies.

### 3 Implementation

We developed a prototype system for a compact refrigerator (VERSOS VS-401) as shown in Fig.2.

The prototype mainly consists of a main board and an acrylic shelf. We formed a shelf in equal size (230 mm x 260 mm) of the refrigerator. We designed the shelf in combination of a transparent acrylic board (5 mm) and a white acrylic board (3 mm) as shown in Fig. 3 left. The size of the shelf is 260 mm x 375 mm. We drilled 60 holes (25 mm radius) in the shelf to cover the following LEDs as shown in Fig. 3 right. We attached 6 x 10 LED arrays on the main board whose size is 160 mm x 220 mm. This size is almost same as the effective area of the shelf. The distance between LEDs is 25 mm x 25 mm.

We attached the main board to the acrylic shelf using spacers and screws at upper and lower sides. This system also provides a magnetic switch to detect the door status (e.g., opening and closing) of the refrigerator. The reed switch works as a trigger mechanism: when the door is closed, the system starts the detection process; when the door is opened, the system starts the display process. These devices are controlled with a micro controller (Arduino Uno<sup>1</sup>).

Next, we explain the detection method and usage procedures.

#### 3.1 Detection method

As mentioned above, the system treats LEDs not only as displays, but also as sensors.

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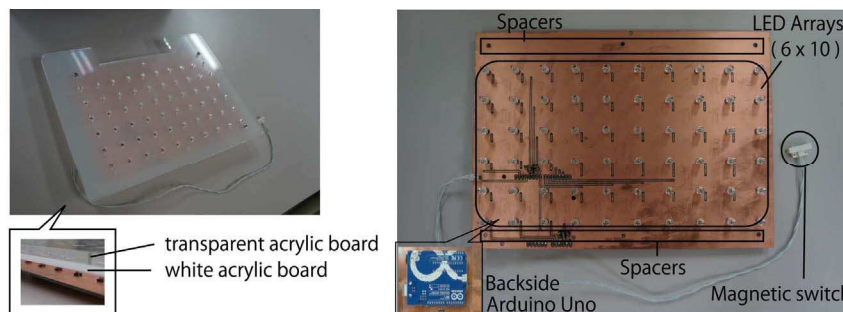
<sup>1</sup> <http://www.arduino.cc/>



**Fig. 2.** Usages of the RefrigeMeter prototype

When the system adds reverse bias voltage to a LED, it can treat the LED as a light sensor by measuring the duration until the cathode voltage drops (voltage drop duration) [4]. The system can detect the existence of items on the LEDs based on this duration that changes along with the brightness of incident light: when the incident light becomes less, the duration becomes longer.

Although this sensing method is often affected by surrounding light, we can offset this weakness since the RefrigeMeter treats a closed space in a refrigerator in which surrounding light looks stable.



**Fig. 3.** Left: appearances of the prototypes, right: device architectures of the prototypes

### 3.2 Usage procedure

As mentioned above, our system starts detection/display processes when the door is closed/opened. We explain usage procedures as follows:

1. When the system is initialized<sup>2</sup> and the door is closed, the system measures voltage drop duration of each LED. The system defines the threshold on each LED to detect whether items are placed based on the initial duration.
2. When the duration is shorter than the threshold on each LED, the system recognizes that an item is placed on the LED.
3. When the door is opened, the system calculates the duration that the items are lo-

<sup>2</sup> Users need to remove items on the shelf in this process.

cated on each LED (item duration).

4. The system activates the LEDs in different frequencies based on the item duration. When the item duration becomes longer, the LED comes to blink in higher frequency.

## 4 Related Work

Many systems have been proposed which support users to organize items in a refrigerator by attaching RFID tags to the items and registering item information to the database [1, 2]. These systems assumed that all items prepared RFID tags, which includes various information (e.g., a food name, quantity and freshness date). However, since RFID tags have not been attached to individual foods even now, these systems required users to attach RFID tags and register these information manually.

Hudson [3] and Akita [4] proposed techniques to apply LED arrays as light sensors and implemented simple applications like touch sensors and interactive tiles in which a user can draw pictures using a laser pointer. We applied these techniques - using LEDs as both sensing/display methods - into a practical application in daily environment.

## 5 Conclusion

In this paper, we propose a novel interactive surface, "RefrigeMeter", which can automatically detect the positions of items placed in the refrigerator and informs users of their duration. Using the RefrigeMeter, users can obtain the status of items at a glance just by getting/putting the items as usual. We plan to improve our system by applying machine learning techniques for better sensing accuracy and by exploring the effectiveness through user tests in daily environment.

## Acknowledgements

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## Citations

1. C.W.Lee, S.J.Lee, M.Kim: Capacitive Humidity Sensor Tag Smart Refrigerator System using the Capacitive to Voltage Converter (CVC). *International Journal of Advanced Science and Technology*, 15-26 (2011).
2. J.Lindsay, W.C.Reade. RFID system and method for tracking food freshness. U.S.Parent 6,982,640. 2006-1-3.
3. S.E.Hudson. Using light emitting diode arrays as touch-sensitive input and output devices, 287-290, In Proc. UIST 2004, ACM Press.
4. J.Akita. Interactive Matrix LED Unit with Pattern Drawing and Extensive Connection, In Proc. SIIGRAPH'10, ACM Press.