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Smart Kitchen Cabinet for Smart Home

[1] Soumya Patil , [2] Shriya Bagmar ,[3] Smita More [4] Rachel Joseph
Department of Instrumentation Technology
B V Bhoomaraddi College of Engineering and Technology, Hubli, Karnataka, India
[1] soumyapatil94@gmail.com

Abstract- **This paper describes a conceptual design of a Smart Kitchen Cabinet, a system for maintaining inventory status of grocery items in the kitchen automatically. This system incorporates grocery item identification, inventory management of grocery items and automatic generation of shopping list. Individual grocery items can be equipped with sensors to detect how full they are. The Smart Kitchen Cabinet consists of two different sections each leveraging two sensing mechanisms: weight sensing and level sensing. Level sensing section consists of fixed size container having RFID tag defining container size with product description, RFID tag reader, and an Ultrasonic level sensor for measuring the level of contents in the container. On the other hand the weight sensing section consists of RFID tags with similar container specification and content identification, RFID tag reader, and weight sensor measuring all the contents on that shelf. The embedded sensors measure the weight or the level of the items which is updated to the database whenever grocery items are placed or taken out for cooking. When the items reach the predefined threshold level, the system generates the automated shopping list.**

Keyword - Smart Kitchen Cabinet; Weight sensing; Level Sensing; RFID tag; Inventory Management.

I. INTRODUCTION

Imagine a visit to the supermarket on the way to home from work. You stop to buy milk because you realised that there is no milk at home. While at the store, it dawns on you that you might be low on cereal and you'd like to avoid another visit tomorrow. But you don't recall….[1] or imagine yourself coming home from the grocery store realizing you bought too much of one thing or not enough of another.

In such scenario Smart Kitchen technology comes handy. Therefore this idea of Smart Kitchen Cabinet intends to manage grocery items in the kitchen along with generating the shopping list. The kitchen cabinet is augmented with sensors to measure the weight of the items or level of contents in the container in order to update it to a database. The database helps in generating the shopping list for the items which have reached the defined threshold level.

The features of the proposed system are as follows:

1) An Inventory Management System for kitchen grocery items.
2) Notifications to alert the user through email or SMS to indicate grocery required.
3) Shopping list generation.

Here, grocery item sensing is done in two ways:

1) Weight sensing : The weight of every item that has a unique RFID tag is measured and sent to the database.
2) Level sensing: The level of content of fixed size containers that has a unique RFID tag is measured and sent to the database.

The remaining of the paper is organized as : Section II discusses about the related work in this area. The system architecture is described in Section III. The Algorithms are presented in Section IV. The limitations of the Smart Kitchen Cabinet are mentioned in Section V. Conclusion and Future works are described in Section VI.

II. RELATED WORK

In this section, we envisaged several related works from this domain.

In paper [2], the authors proposed a system to re-identify grocery items using Load Balance feature on the shelf for monitoring grocery inventory. They demonstrated it by means of a prototype device and the two simulated experiments. The experimental results show that when grocery items are put on the load-sensing board in neat rows fairly accurate grocery re-identification is obtained. It also shows that some grocery items are incorrectly identified as others even with the

load feature, when one of the grocery items having similar weight to another is stacked on it.

Chih-Chin Liang [3] presented a Smart Inventory Management System of Food-Processing and Distribution Industry. This study proposed a prediction model composed with factor analysis tool. The factors are obtained through AHP method and surveying experts. To predict the forthcoming items in an inventory the survey results are applied to sequential-pattern analysis. The study summarized the three major concerns (quantity of stored foods, the recency of input/output foods, and the input/output frequency of the same foods) of a food-processing and distribution company as QFR (quantity, frequency, and recency), and weighted each factor to calculate the significance of each item in inventory. The best accuracy of inventory prediction is 66.3% through this proposed prediction model.

LiveItUp! 2 Smart Refrigerator [4] is an improvement in vision-based object detection and identification of food inventory for their previously developed prototype LiveItUp! 2 Smart Refrigerator [5]. The authors have used several image processing methods like motion detection, Thresholded Euclidean Difference, blob processing and cropping. The system can identify multiple items. Object identification and recognition without crashing is controlled by image processing application. They tested image processing application first by detecting a pizza and then by adding other items such as a Cheez Whiz spread and a circular tupperware. They observed that the image processing application detected all the items. But the processing was slower for multiple item detection compared to single item detection.

Context-aware cooking [6] is implemented using augmented cutting board and sensor enriched knife. Load and acceleration sensors are fixed to the cutting board to identify the type of food used. A camera to detect the object and a microphone is used to recognize the cutting sound.

III. SYSTEM ARCHITECTURE

This section comprises technical description, functionalities of components utilized and describes overall system designs.

A. Device Specifications

RFID tags are used for identifying the item and are attached to the containers. Every item will contain a universal tag identifier and the grocery item name as product code.

RFID antenna is mounted inside the cabinet that would read the information stamped on the tags. This antenna obtains useful information by communicating with tag antenna in order to transmit it to our application.

Level Sensor: The level sensor used is UCL – 520. It is a general purpose ultrasonic continuous level sensor. The sensor is used to sense solid and liquid substances based on non contact sensing.

Weight Sensor: SH series Load cells are employed as Weight sensor. These are high accuracy Load cells with 1102 to 22050 lbs load rating.

B. System Design and Working

This section describes the technical design of Smart kitchen cabinet.

Each container in the cabinet is equipped with RFID tag. The RFID antenna is mounted at the top corner of the cabinet. The cabinet has 2 shelves. One shelf will hold a level sensor and the other shelf will have a weight sensor mounted under its floor. The sensors send the data to the application through a wireless router. The application will then analyze the data, detects the item and store weight or level in database separately for both the shelves. Then the appropriate algorithm is performed and finally the user is notified if necessary. The functional block diagram of proposed system is as shown in figure 1.

The user can set the threshold for each grocery item. The application interacts with the user through smart device. The following are the tasks performed by the application:

1) Allow the user to set threshold for different items.
2) Notify the user whenever an item's quantity reaches below threshold level through SMS or email.
3) Generate Shopping list automatically with those grocery items.
4) Enable user to know the status of all items whenever required.

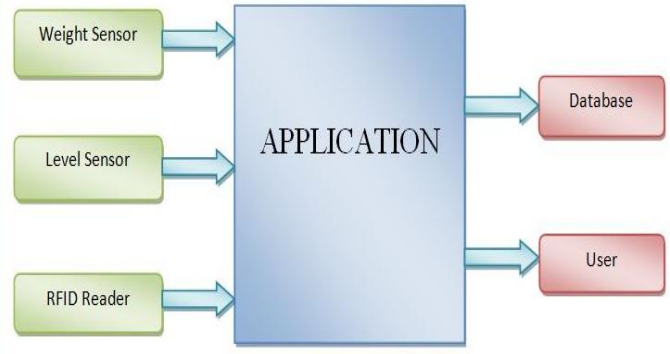

Fig. 1 Functional block diagram of Smart Kitchen Cabinet

C. Graphical User Interface

GUI is designed for the user to easily manage the kitchen inventory and shopping lists. The interface consists of two main components: Inventory list and a Shopping list as shown in figure 2. The items placed and detected in the cabinet are viewed in the inventory list along with their quantities. The inventory list is as shown in the figure 3. The items in red are the items which have reached the threshold level. Hence these items are added to the shopping list along with their current and required quantities. The shopping list is as shown in figure 4.

Fig. 2 GUI showing Home Page

Fig. 3 GUI showing Inventory List

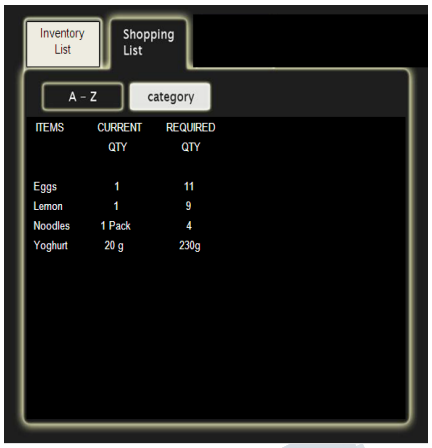

Fig. 4 GUI showing Shopping List

IV. ALGORITHM

This section describes few possible algorithms to support inventory management. The following events take place in the cabinet:

1) Addition of a new item or container to the inventory.
2) Deletion of an existing item or container from the inventory.
3) Deletion of an existing item or container from the inventory to use it and put it back.

A. Detection and tracking of items in the shelf having weight sensor

This section describes the pseudo-code for identifying and tracking of grocery items in the shelf having weight sensor.

W_N - output of weight sensor at N th state
W_{N-1} - output of weight sensor at (N-1)th state
RF_N - set of RFID tags of shelf at Nth state
RF_{N-1} - set of RFID tags of shelf at (N-1)th state
Th - Threshold

```
IF (( W_N - W_N-1 ) > Th )
   {
      IF ( W_N > W_N-1 )
           {
           // New item has been arrived
            Incoming Item tag = RF_N - RF_N-1
            Item weight = W_N - W_N-1
            }
     ELSE
           {
           // Existing item has departed
            Departed Item tag = RF_N-1 - RF_N
             Item weight = 0
            }
   }
```

B. *Detection and tracking of items in the shelf having level sensor*

This section describes the pseudo-code for identifying and tracking of grocery items in the shelf having level sensor.

L_N - output of level sensor at N th state
L_{N-1} - output of level sensor at (N-1)th state
RF_N - set of RFID tags of shelf at Nth state
RF_{N-1} - set of RFID tags of shelf a t(N-1)th state
Th - Threshold

```
IF  ( ( L_N - L_N-1  ) > Th )
   {
       IF  ( L_N > L_N-1  )
            {
            // New item has been arrived
             Incoming Item tag =  RF_N - RF_N-1
             Container level =  L_N - L_N-1
             }
      ELSE
            {
            // Existing  item has departed
             Departed Item tag =  RF_N-1  -  RF_N
              Container level =  0
             }
    }
```

C. *Shopping List Generation Algorithm*

This section describes the procedure which generates the notifications to the user. The following pseudo code can be implemented in the database:

W_{Th} - Threshold of weight for an item
L_{Th} - Threshold of level for a container

```
IF ( ( W_N <  W_Th ) or ( L_N  <  L_Th ) ) THEN

Notify user
Get item name from RFID
Add item to shopping List

END
```

V. LIMITATIONS

When an item in the container is changed, the user needs to update it. The shelf having level sensor will work only if the containers have a transparent cover. Whenever user takes out an item for temporary use and forgets to keep it back in the cabinet , the item will be added to the shopping list automatically.

VI. .CONCLUSION AND FUTUREWORK

The proposed system is an effort towards Smart Kitchen. The system includes two sensing techniques - level sensing and weight sensing. This system is capable of identifying the grocery items and track their usage. It is a conceptual idea and can modernize the inventory management of kitchen when implemented . It can also be implemented to endorse the Smart Home applications and turn out to be an indispensable prototype.

The smartness of the kitchen cabinet can be further enhanced by adding more features like edition of shopping list and sending it to grocery store, product expiration management, diet monitoring ,storing nutrient values of each item, and provide online recipes which can be cooked from the existing grocery items.

ACKNOWLEDGMENT

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