

NeverFull

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Abstract —In modern world, high-tech products are widely applied to all kinds of industries. However, in restaurants and bakeries it still requires a lot of human resource that costs a lot and is likely to make mistakes. NeverFull provides powerful functions to recognize different types of food. Shop owners can build the database easily by themselves to save a lot of time and effort.

Keywords —

I. INTRODUCTION

To make transactions easier (we focus on bakeries in this project), we think that it'll be a lot better to improve the efficiency of checkout process. Our system captures the image of bread, and analyzes the edge information of each image. After that, the system compares the images and recognizes the type of bread. With the user-friendly interface, customers can pay their bills easily.

II. FUNCTION

A. Device

1) DE2-115(with the power cord and the USB cable) (fig.1)

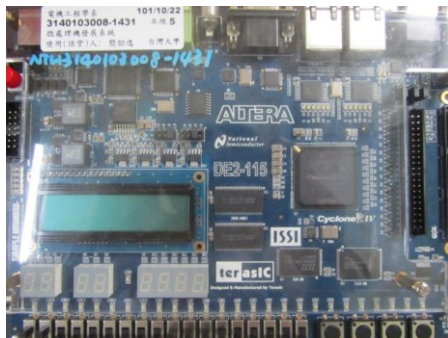


Fig.1

- a. 7-segment displays: Show the mode, the number of the picture and the price from left to right.
- b. Switches and Buttons:

Switches and Buttons	Instruction
SW[17]~SW[16]	Mode switch.
SW[14]~SW[4]	Set the sensitivity of the detection to fit the light condition.
SW[3]	Cut the price by 10/sec.
SW[2]	Cut the price by 1/sec.
SW[1]	Add the price by 10/sec.
SW[0]	Add the price by 1/sec.
KEY[0]	Reset.
KEY[2]	Shooting mode: shutter. Editing mode: switch image.

Fig.2

2. D5M Camera

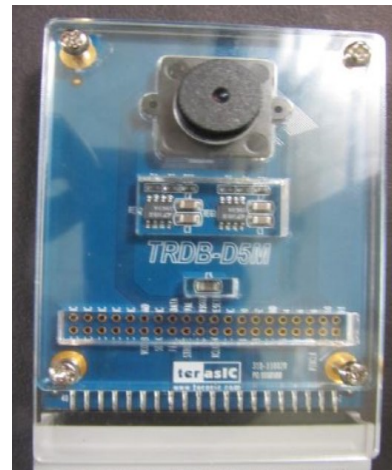


Fig.3

3. VGA Display

Show the current price information.

B. Usage

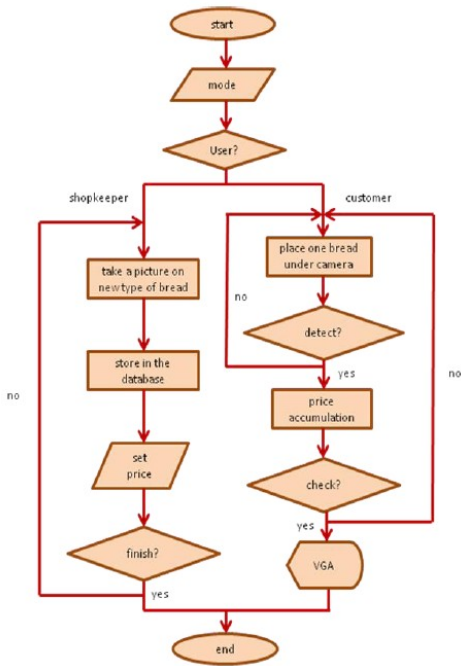


Fig.4

1) Modes

a. Viewing mode

- i. switch: SW[17]OFF,SW[16]OFF,SW[15]OFF
- ii. instruction: showing the image from the camera

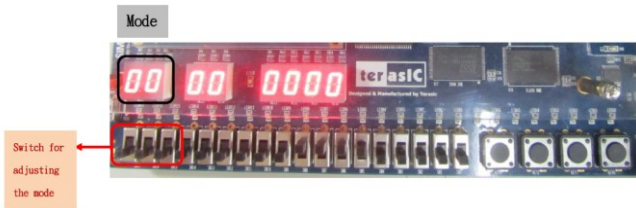


Fig.5

b. Shooting mode

- i. switch: SW[17]OFF,SW[16]ON,SW[15]OFF
- ii. instruction: Set up the database of the food.
- iii.usage: Click KEY[2] for taking a shot.

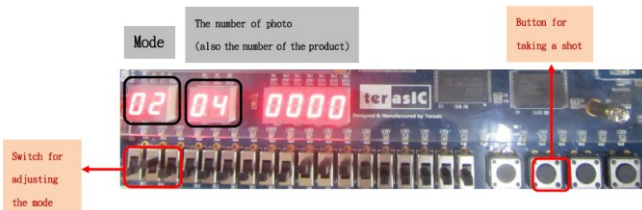


Fig.6

Editing mode

- i. switch: SW[17]OFF,SW[16]ON,SW[15]ON
- ii. instruction: Adjust the price of the food in the database.
- iii.usage: Click KEY[2] for selecting the food and turn on SW[0]-SW[3] to change the price.

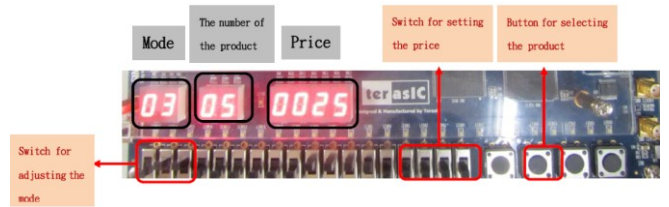


Fig.8

d. Recognition mode

- i. switch: SW[17]ON,SW[16]OFF,SW[15]OFF
- ii. instruction: Putting the bread in front of the camera, the system will recognize the type of bread based on the database and accumulate the price automatically.



Fig.9

Checkout mode

- i. switch: SW[17]ON,SW[16]ON,SW[15]OFF
- ii. instruction: After scanning all the product they buy, customers can switch to Checkout mode to check the total price for this consumption.



Fig.10

2) Setting for owners

Step 1: Connect DE2-115 with CCD camera and VGA display under sufficient light. After that you can turn the power on.

Step 2: Switch to shooting mode. Press KEY[2] to take the photo of the bread you want to store into database.

Step 3: Switch to editing mode to view the taken photos. Use KEY[2] to switch the photos and set the price by SW[0]-SW[3]. The price will be displayed on 7-segment display.

Step 4: Switch to recognition mode. Consumers can check out by themselves easily.

3) Setting for consumers

Step 1: Put the bread in front of the camera. Several seconds later, the system will identify it and accumulate the consuming amount.

Step 2: After all the bread identified, switch to checkout mode. You'll see the price on the VGA display.

III. ARCHITECTURE

A. Block diagram

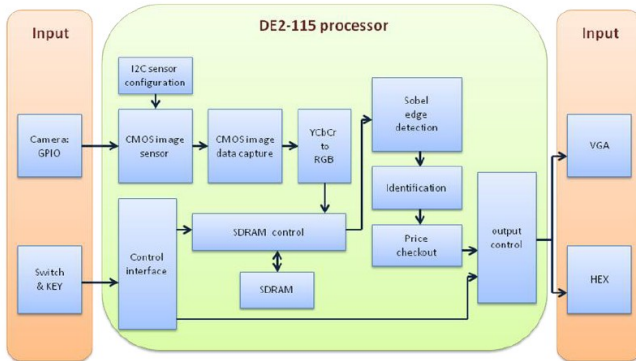


Fig.11

B. CMOS image sensor

1) First we need to set up some parameters of CMOS image sensor (SDAT) with the corresponding time diagram (SCLK) of I2C.

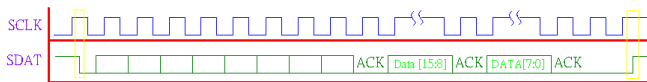


Fig.12

We send in 25MHz clock signal to the parameter "XCLKIN" of the CMOS image sensor and the chip will input the image data and corresponding FVAL, LVAL, PIXLCLK signals for user.

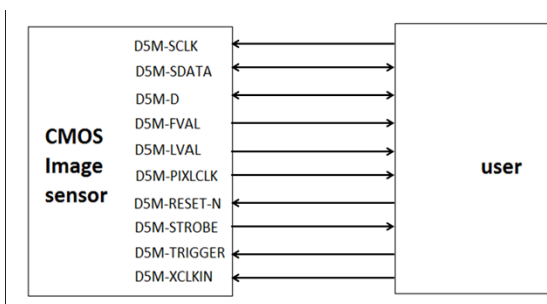


Fig.13

C. Image input

1) The input image can be thought as a frame composed of 2752x2004 pixels of 12-bit data, 2592x1944 of which represent active image/valid image and others represent boundaries.

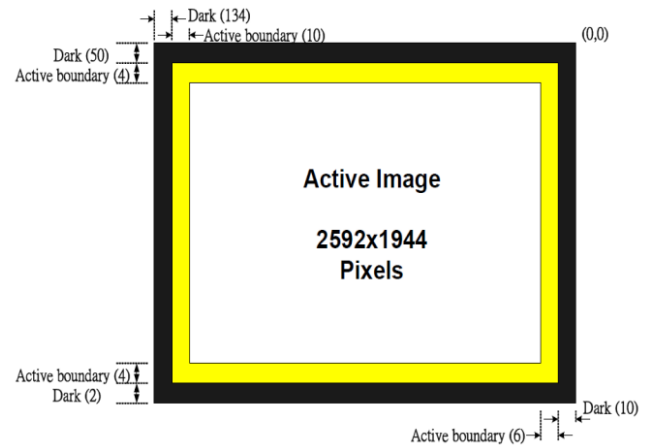


Fig.14

2) The 12-bit data is pumped in with PIXCLK by sequence rather than array. Only when FVAL and LVAL equal to one at the same time are the data needed.

3) The output will be in RAW. It should be transformed to RGB for further usage.

D. SDRAM

We use the first 600x800 bytes of the SDRAM as a buffer between image input and further processing. Other space serves as the memory for the images taken by the camera.

E. Sobel edge detection

We use Sobel edge detection algorithm to capture the edge information for image recognition. To know whether a pixel is an edge point, we compare the 8 surrounded pixels of it with below formula.

$$|G| = |(P1+2 \times P2+P3)-(P7+2 \times P8+P9)| + |(P3+2 \times P6+P9)-(P1+2 \times P4+P7)|$$

If $|G|$ is larger than the threshold value, which can be set with SW [4:14], the pixel is recognized as an edge point and its output value, named wSobel, will be one.

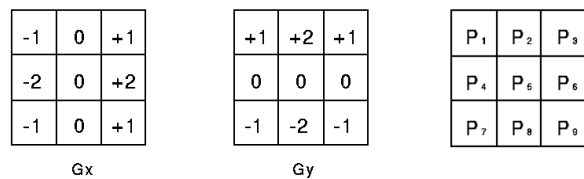


Fig.15

In our design, we use submodule "Sobel" to capture the data from SDRAM buffer and output wSobel. In recognition mode, wSobel value will be output to VGA display to show the edge detection result.

F. Recognition

After capturing the edge information of the image, we begin to analyze it for recognition.

For each edge pixel (its wSobel equals to 1), we calculate its distance from the central pixel of the image. For simplicity, we use $|H_cont-H_central| + |V_cont-V_central|$ here to present the distance instead of $((H_cont-H_central)^2 + (V_cont-V_central)^2)^{1/2}$. After VGA controller scans all pixels (800x600) of a image, we get the identity number of

the image, which is the sum of all the distance of the edge.

Since we use the distance information for identification, the system also works in the case the bread is shifted or rotated.

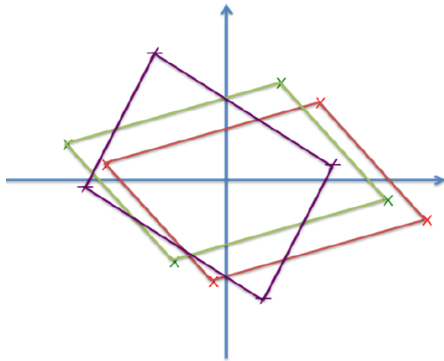


Fig.16

G. Price calculation

The system will repeatedly calculate the identity number. If the identity number keeps the same (or stays in a small range) for 100 consecutive times, the system will search the database to choose its correspondent.

After identification, if the product is not moved away immediately, it will be seen as the same one, and total price will not increase. If the customer changes the product and put a new one, the system will start the recognition process once again.

Notice that the switch of modes will lead to restart. If customers want to check total price, they should move the product away in front of the camera.

H. VGA output:

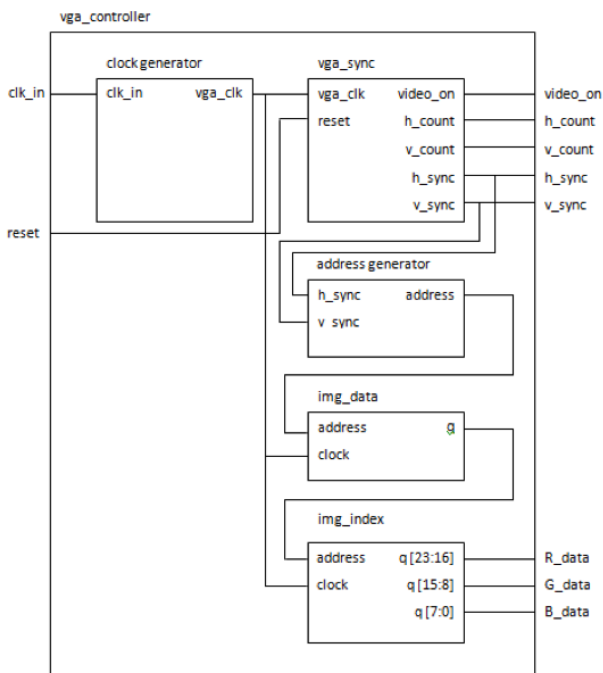


Fig.17

We use the module “vga_controller” to control the screen. The diagram of module is shown above. The system converts the clk_in sent from outside to vga_clk for VGA

display, and gets h_count(horizontal axis) and v_count(vertical axis). Both h_sync and v_sync are boundary conditions. Only when h_count and v_count are in the valid range can RGB signal be shown on the display.

The valid range is 800x600. The origin is on the top left and the go through down right. The variable h_count increases first, and v_count increases when h_count meets the rightmost boundary. The frame is shown completely when v_count is at the bottom, then h_count and v_count recalculate from top left again.

Start

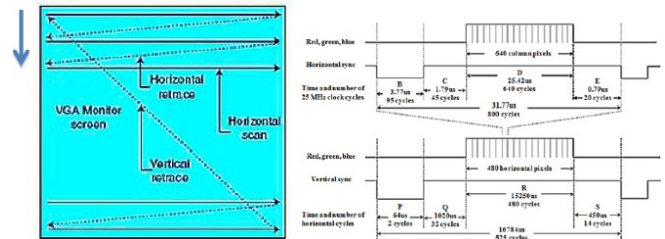


Fig.18

Each point at (h_count, v_count) has its own RGB value, and is shown on the corresponding location of screen. The RGB value can be transferred from camera, from SDRAM, or set by designer. In viewing mode, the value is produced by camera and translated by a buffer(we use SDRAM here). In editing mode, the value is read from SDRAM and send through Sobel edge detection. The black-and-white result will be shown by VGA controller. In checkout mode, we set the RGB variable for every area so that the total account is “drawn” on the screen by ourselves.

IV. EFFICACY

A. Compiling information

Flow Summary	
Flow Status	Successful - Thu Jul 25 16:00:12 2013
Quartus II 32-bit Version	12.1 Build 243 01/31/2013 SP 1 S1J Web Edition
Revision Name	DE2_115_CAMERA
Top-level Entity Name	DE2_115_CAMERA
Family	Cydome IV E
Device	EP4ACE115F29C7
Timing Models	Final
Total logic elements	5,759 / 114,480 (5 %)
Total combinational functions	5,368 / 114,480 (5 %)
Dedicated logic registers	1,880 / 114,480 (2 %)
Total registers	1880
Total pins	464 / 529 (88 %)
Total virtual pins	0
Total memory bits	76,552 / 3,981,312 (2 %)
Embedded Multiplier 9-bit elements	30 / 532 (6 %)
Total PLLs	1 / 4 (25 %)

Fig.19

B. Independent variables

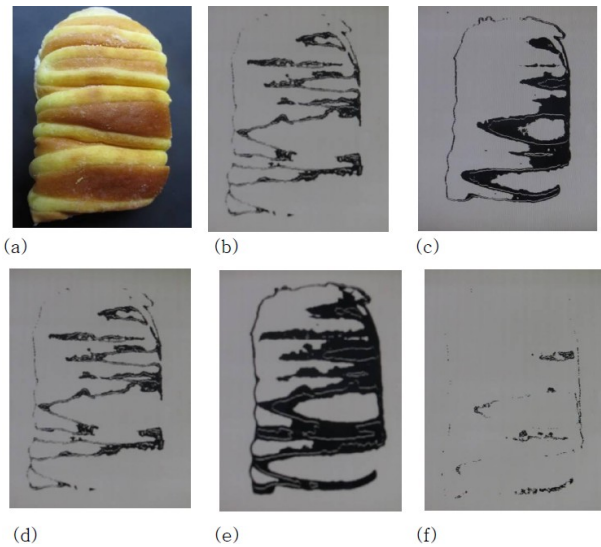


Fig.20

Pictures (a) to (c) are on original, even lighting and uneven lighting conditions respectively, and pictures (d) to (f) are with normal, darker and brighter light. The key is whether the edge of the product can be detected clearly. We found accurate recognition happens in even lighting environment, and the false results may occur when light is uneven. Instead of using direct light source, we let the light reflect from aluminum foil to make system stable.

V. CONCLUSION

NeverFull makes the checkout process faster and more efficient. The features of NeverFull are simple operations and convenience. Shop owners can build their own database and apply this system on more and more products. NeverFull also provides friendly interface. In terms of customers, NeverFull is easy to use because of the simple steps. Fast recognition and automatic checkout reduce their waiting time. We expect to improve economic development by this new product — NeverFull.

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