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# Color-based automatic quality control for roasting chicken

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ABSTRACT

In this paper, we develop a color-based automatic control system for roasting chicken industry by using the modern Combi Oven and new image processing techniques. Firstly, we embedded a video camera into the Combi Oven and design a color monitoring system. Secondly, a new segmentation technique based on level set approach is developed. Thirdly, a new color indicator is defined for color quality control. Finally, extensive experiments have been conducted to validate the proposed segmentation approach and the effectiveness of the developed system.



## 1. Introduction

The color change on roasted food surface is a very important quality indicator for bakery industry (Purlis, 2010). The evenly yellow-gold color of food surface is generally one priority quality parameter evaluated by many consumers; as such color is usually indicating tasty flavor and high level of satisfaction (Purlis, 2010; Chmiel et al., 2011). Such color-based quality control should be used in several roasted foods, such as roast chickens, roast duck, roast suckling pig, roast pork knuckle, bread, and flaky pastry. Usually the color transformation is from shallow to deep in a gradual process during the roasting, and controlling the browning quality is usually depending on the manual temperature and time control based on workers' experience with different equipment.

Traditionally, the visual and spectrometric techniques are used for color measurements and control (Figura and Teixeira, 2007). But these approaches are inappropriate for most industrial appliances due to its manually operator-dependency and poor repeatability. The spectrometric techniques like colorimeter in fact only measure the absorption of known wavelengths by sampling in a controlled specified lightening situation (Bowers et al., 2012; Yang et al., 2015), and the measured results cannot be used for global quality analysis, since the measuring surface is usually rather small (Arturo et al., 2008). Furthermore, implementing these methods is usually slow in the food processing device because of the sampling and preparation and may even fail in an appropriate processing condition for real-time process manipulations (Mortaza et al., 2014).

Recently, the Combi Oven, as advanced commercial cooking equipment, has become increasingly popular in food industry (Zhuang and Savage, 2008). Though the Combi Oven can replace cooking needs ideally for a steamer, grill, and convection oven through controlling temperatures and humidity levels (Marzena et al., 2007), it, as a high-end device of cooking, cannot automatically and directly control color changing process. Moreover, the interior of most old oven equipment is dim because of using the warm-white light source for interior illumination. Therefore, they are difficult to monitoring the actual level of browning food directly only based on human inspection, and impossible by using image processing techniques as the captured images are blurred intensively. The Combi Ovens have adopted the new white light source and provide possibility for automatic control via image processing techniques.

Nowadays, the idea of designing automatic image processing system for food quality control has been explored intensively (Wu and Sun, 2013; Brosnan and Sun, 2002; Sun, 2004; Kang and Sabarez, 2009; Mortaza et al., 2014). Among these developments, the off-line computer vision systems are considered improper for many actual applications, especially for roasting and bakery, due to the inability to provide the real-time information. Nevertheless, the on-line computer vision system is a rapid and non-destructive approach that is well suited for color analysis in food industry (Mortaza et al., 2014). Thus, the on-line computer vision system has a potential to revolutionize the current baking system not only

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for color measurements but also for better understanding and controlling of the food quality based on color changing.

Because conventional ovens are far less powerful than the Combi Ovens in temperature and humidity control (Zhuang and Savage, 2008; Marzena et al., 2007), the latter is more suitable for adding some potential new functions for quality improvement. In this paper, we aim to design an effective quality control system for roasting chicken by developing a video camera monitoring system for color browning process control with the Combi Ovens. To best of our knowledge, this is the first investigation in academic research community on the automatic color control of roasting chicken by using the Combi Oven. Technically, we will add a video camera on the Combi Oven and then develop the image capture and processing techniques. Especially a new segmentation algorithm for the chicken is developed and color changing evaluation is conducted via image processing technique. Finally some experiments are conducted and experimental results are analyzed.

The structure of this paper is organized as follows. In Section 2, the proposed system is described in detail. Section 3 will present a segmentation approach to identify the area of the chicken objective. Color quality tracking will be conducted in Section 4. We will conduct some experiments in Section 5 and conclusions are given in Section 6.

## 2. Automatic monitoring system design for roasting chicken

The original Combi Oven does not have a camera installed. In order to develop a workable system, we first put a camera in the front door handle to testify our idea. Once the idea is validated, we can install a high quality camera inside the oven engineering to provide control mechanism for the roasting process. The experimental video image acquisition system is shown in Fig. 1.

Also a computer is connected to the video camera for image processing. Instrumentally, camera apparatus and image processing have to be designed and added into the original Combi Oven system. A mini-camera toward food is installed in the interlayer of chamber side and linked the interior embedded systems. On the other hand, an added computing module as an images information processing unit is responsible for extracting the food area and tracking the color indicator, in order to control the cooking process when the color meets a preset satisfactory level. Meanwhile, interior illumination equipment adopts the white light source instead of the warm-white light source. The images information processing unit is in charge of image process with flowchart as shown in Fig. 2.

Technically, when video images are captured, each frame from the video is put into the image information processing unit. Of course, at the chamber preheating stage, the background image can be obtained. In the roasting stage, the first frame and the background frame are used to perform background subtraction to create a binary image with only rough chicken area. A maximum rectangle hugged the area can be detected and regarded as a rough chicken area boundary. Next, we need to extract an exact area of chicken by a segmentation technique developed in this paper, called the adaptive balanced level set evolution (ABLSE). Finally, a color indicator of chicken is established and computed for each sample frame. The whole cooking service can be stopped if the color indicator triggers the pre-set value, which is usually obtained by experience.

## 3. Chicken area segmentation

As the aim is to monitor and control the color changing process of a roasting chicken in the Combi Oven, the extraction of the precise chicken area has to be solved via segmentation. Generally, extracting an object from a given image is an easy task as it is an

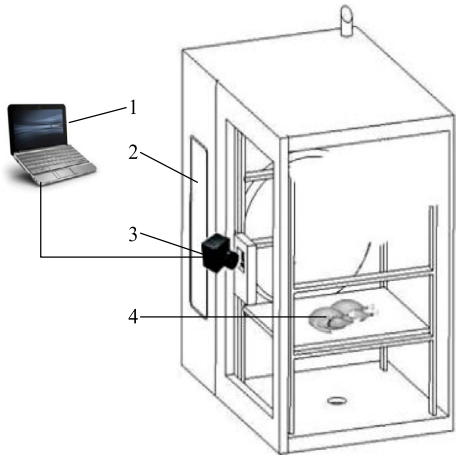


**Fig. 1.** Image Acquisition System for roasting chicken in the Combi-Oven. 1. Computer, 2. Combi-Oven, 3. Miniature camera, 4. Chicken.

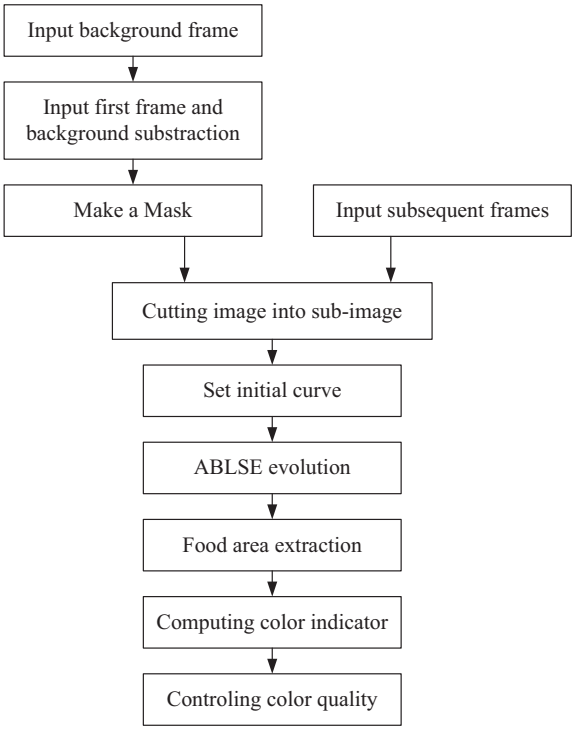


**Fig. 2.** The program flow of our method.

object edge detection problem which has been investigated extensively (Purlis, 2010; Dong and Hu, 2011). However, the results of conventional extraction approaches were unsatisfactory in this case because the size of a chicken was changing slightly in the roasting process and the background is also disturbed by vapor and splashing residues in the roasting process due to changes of temperature and humidity. Therefore, in our study, the Gaussian Average method based on the background subtractions (Massimo, 2005) is used as an auxiliary tool to obtain a rectangular mask and this mask is used as an initial condition at first frame for creating a sub-image for the proposed segmentation approach. This mask is marked as a sub-image in all subsequent frames, tightly wrapped against the food in video processing in order to reduce the computing cost in segmentation.

And then, a new level set based approach is proposed for extracting the chicken area in this paper. In recent years,