IOSR Journal of Engineering
Apr. 2012, Vol. 2(4) pp: 526-528

Visual Inspection of Bakery Products by Texture Analysis using Image Processing Techniques

Jatinder Singh[1] and Maninder Kaur[2]
[1](ECE Deptt., Doaba Institute of Engineering & Technology, Kharar, Punjab INDIA)
[2](ECE Deptt., Doaba Institute of Engineering & Technology, Kharar, Punjab INDIA)

ABSTRACT
The appearance of bread, such as colour and visual texture are important to the consumer when purchasing bread. The perceived colour of bread is a function of its solid-phase crumb, air-phase and viewing conditions, varying with age and ambient lighting. Visual texture aspects include the alignment of fibres with respect to the axis of view and the distribution of small fat regions in both phases. Texture analysis on bread on the other hand is somewhat more subtle. A close inspection of bread stuff reveals that the bread-crumb texture comprises two phases of material; the solid-phase crumbs appear connected, while the air-phase crumbs are scattered randomly at isolated regions.
In general, the thickness of the cell walls affects grain quality greatly. Thin cell walls are more prevalent in fine textured crumbs, and thick cell walls are generally found in coarse crumbs. It can also be seen from these figures that the distribution of phases within the crumb structure may be irregular, but the volume fraction properties are statistically and essentially homogeneous. Thus the overall textural properties of the bread crumb can be studied from images taken from different regions of a whole bread-crumb specimen. In the proposed work, a 2-D Haar transform together with canonical discriminant analysis is used for texture analysis in bread stuff in bakery industries.

I. INTRODUCTION
Texture analysis refers to the characterization of regions in an image by their texture content. Texture analysis attempts to quantify intuitive qualities described by terms such as rough, smooth, silky, or bumpy as a function of the spatial variation in pixel intensities. In this sense, the roughness or bumpiness refers to variations in the intensity values, or gray levels. Texture analysis is used in a variety of applications, including remote sensing, automated inspection and medical image processing. Here, we propose a texture based analysis of baked food items so as to determine their baked quality. As the consumers are becoming more sophisticated and the demand for healthy food is increasing, food texture is becoming a very important issue for food processors. Texture analysis can be used to find the texture boundaries, called texture segmentation. Texture analysis can be helpful when objects in an image are more characterized by their texture than by intensity, and traditional thresholding techniques cannot be used effectively.

II. BRIEF LITERATURE SURVEY
Although no formal definition of texture exits; however, texture analysis provides measures of properties such as smoothness, coarseness and regularity [1]. There are three principal approaches in image processing are statistical, structural and spectral. Statistical approaches yield characterization of textures as smooth, grainy and so on. Structural techniques deals with the arrangement of image primitives such as description of texture based on regularity spaced parallel lines. Spectral techniques are based on properties of the Fourier spectrum and are used primarily to detect global periodicity in an image by identifying high energy, narrow peaks in the spectrum [3]. With the advent of computer vision technology together with the falling cost of processors, the responsibility for baked food inspection is shifting to an intelligent machine [5]. The use of digital vision systems has helped to reduce the number of manual inspectors and allows the possibility of automating the process. The shape, size, and color of most baked foods have been studied in great detail, but the study of texture is focused mostly on bread crumb [7]. Baking results in changes in the four most important quality characteristics of a typical bakery product – color, shape, size, and texture [6]. The rate of changes of these parameters depends on the ingredients used in the dough, as well as the baking environment (such as temperature and time). Hence, measuring the kinetics of these quality parameters during and after baking allows optimal control of food quality, ensures the safety of the final product, and reduces production losses caused by the inherent fluctuation in physical properties – principally, the properties of the dough piece [9].

III. BREAD STUFF BAKING PROPERTIES
The main ingredients of bakery products are flour, water, sugar, fat, and salt. A variety of shapes, colors, sizes, and textures may be produced by varying the proportions of these ingredients. Another factor which is of considerable importance in bakery is the dough. Properly baked dough then leads to a product with superior quality and sensory features. Fresh products usually present an appealing brownish and crunchy crust, a pleasant roasty aroma, fine slicing characteristics, a soft and elastic crumb texture, and a moist mouth feel. Baking is the last and very important part of the process. Baking induces many biochemical reactions within the dough, triggering a series of complex physicochemical changes ranging from the formation, development, deformation, and expansion of gas cells to

modification of rheological properties. The most important physical changes are due to the Maillard browning reaction.

IV. IMAGE GRABBING

Images of bread stuff is grabbed using CCD camera of resolution more than 5 mega pixel. Image quality at resolution of 5 mega pixel or above give a fair representation of the bread stuff for analysis purpose. Following images shows the bread stuff quality taken using the Nikon 5 mega pixel camera from a close distance. Fig. 1 and 2 shows the original image and thresholded image using Otsu algorithm respectively.

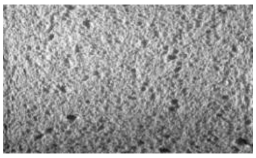


Fig. 1

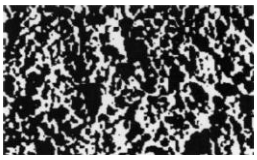


Fig. 2

V. BREAD STUFF TEXTURE ANALYSIS

Texture analysis can be helpful when objects in an image are more characterized by their texture than by intensity, and traditional thresholding techniques cannot be used effectively. Texture can be roughly defined as the combination of some innate image properties, including fineness, coarseness, smoothness, granulation, randomness, lineation, hummocky, etc., a strictly scientific definition for texture has still not been determined. Accordingly, there is no ideal method for measuring texture. Nevertheless, a great number of methods have been developed, and these are categorized into statistical, structural, transform-based, and model-based methods. These methods capture texture measurements in two different ways – by the variation of intensity across pixels, and by the intensity dependence between pixels and their neighboring pixels.

VI. COLOR INSPECTION

Most baked products consist basically of sugar, eggs, flour, baking powder and water. Once these ingredients have been combined and the mixture appropriately shaped, it is baked in a hot oven for a specific time. When displayed, the baked product exhibits an attractive, shining, golden-brown surface, normally referred to as the “top part.” As the baking time is rather short and the temperature inside the oven is not uniformly distributed, variation in color is likely to happen. This variation indicates the degree of cooking and thus the product quality.

VII. ALGORITHM

In analyzing bread-crumb texture, a two dimensional Haar transform together with canonical discriminant analysis is used. The Haar transform is based on orthogonal matrices of size $i2 \times j2$ for $i, j = 1, 2, 3, \ldots N$, and whose elements are 1, −1, or 0 multiplied by the power$\sqrt{2}$.

The sign of each element is determined by its position in the Haar basis matrix. An example of an 8×4 Haar mask showing the sign of each element is shown in below figure.

$$\begin{bmatrix} + & + & - & - \\ + & + & - & - \\ + & + & - & - \\ + & + & - & - \\ - & - & + & + \\ - & - & + & + \\ - & - & + & + \\ - & - & + & + \end{bmatrix}$$

Steps-1: Position the Haar mask at each discrete location of the bread-crumb image and the gray value of each overlapping pixel is multiplied by the corresponding element of the Haar matrix.

Step-2: Add all the values algebraically to obtain the final Haar coefficient.

Step-3: Slide the mask to a new location in the image, and go to step-1 and repeat over the entire image.

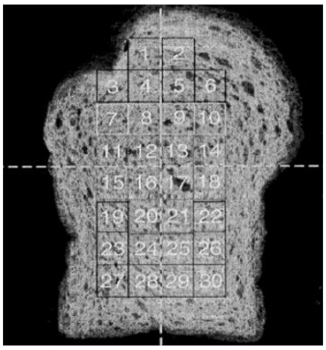
Mathematically, this procedure is equivalent to dividing an image into four rectangular surfaces, summing the gray values of the opposite surfaces and subtracting those that are different. Therefore, each Haar’s coefficient represents the texture or structure of the bread-crumb image at each discrete location in two-dimensional space.

The number of the Haar’s coefficients is clearly dependent on the size of the Haar mask and the image. For instance, given an image of size 512×312 pixels, the 16×64 and 256×256 Haar masks produce 256 and 4 Haar coefficients respectively. The coarser mask may not be representative of the texture characteristics, and the finer mask may take longer to calculate.

The texture of an image is described by a vector of 66 positive numbers called texture characteristics. These parameters are fed to the stepwise-based discriminant analysis, from which they identify the images of bread crumb. Of 66 texture characteristics, 6 textures were sufficient to discriminate bread-crumb images, yielding an average correct classification of more than 82 percent.

VIII. RESULTS

The grading is based on the bread-crumb texture, where the superior category consists of bread crumbs exhibiting very fine and elongated cells, uniformly layered with light, lacy, and very thin cell walls, whilst inferior categories included bread crumbs having cells that are coarser and extremely irregular in both shape and size. An example of the bread-slice image used in the study is shown in below figure.



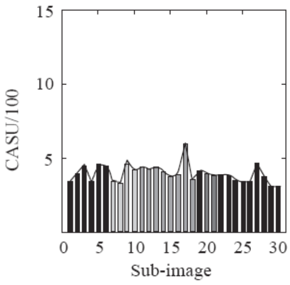


Fig. 2 Fig. 3

In grading, the slice image was segmented into 30 regions of 32×32 equal pixels. The main feature used was the percentage area of the bread crumb. Fig. 3 shows the area of bread crumb of the respective 30 sub-images.

Conclusion

The quality of bakery products is influenced by the combination of dough formulation and processing parameters. Among the latter, it appears that baking itself is the most important part of the bakery process because it triggers a series of physical and biochemical changes in the final output. Baking results in changes in the four most important quality characteristics of a typical bakery product – color, shape, size, and texture. The rate of changes of these parameters depends on the ingredients used in the dough, as well as the baking environment (such as temperature and time). Hence, measuring the kinetics of these quality parameters during and after baking allows optimal control of food quality, ensures the safety of the final product, and reduces production losses caused by the inherent fluctuation in physical properties – principally, the properties of the dough piece. Traditionally, human inspectors have been the only option for evaluating these quality parameters, grading and rejecting samples with unacceptable defects. With the advent of computer vision technology together with the falling cost of processors, the responsibility for baked food inspection is shifting to an intelligent machine. The use of digital vision systems has helped to reduce the number of manual inspectors and allows the possibility of automating the process.

ACKNOWLEDGEMENTS

We are thankful to Mr. Vikas Goel, Sr. Project Manager, C-DAC, Mohali, Punjab for his valuable guidance and continuous support in making this paper.

REFERENCES

[1] Abdullah MZ, Abdul-Aziz S, Dos-Mohamed AM (2000) Quality inspection of bakery products using color-based machine vision system. Journal of Food Quality, 23, 39–50.

[2] Anese M, Manzoco L, Nicoli MC, Lerici CR (1999a) Antioxidant properties of tomato juices as affected by heating. Journal of the Science of Food and Agriculture, 79, 750–754..

[3] Baisier WM, Labuza TP (1992) Maillard browning kinetics in a liquid model system. Journal of Agricultural and Food Chemistry, 40, 707–713. [4] W. K. Pratt, Digital Image Processing. New York, NY, USA: Wiley-Interscience, second ed., 2001.

[5] Bloskma AH, Bushuk W (1988) Rheology and chemistry of dough. In Wheat Chemistry and Technology, Vol. 2 (Pomeranz Y, ed.). St Paul: American Association of Cereal Chemistry, pp. 131–217.

[6] H. Barrett, C. Abbey, and E. Clarkson, "Objective assessment of image quality. iii. roc metrics, ideal observers, and likelihood-generating functions," Journal of the Optical Society of America A, vol. 15, no. 6, pp. 1520–1535, 1998.

[7] Cronin K, Preis C (2000) A statistical analysis of biscuit physical properties as affected by baking. Journal of Food Engineering, 46, 217–225.

[8] Gallagher E, Gormley TR, Arendt EK (2003) Crust and crumb characteristics of gluten free breads. Journal of Food Engineering, 56, 153–161.

[9] Gunasekaran S, Ding K (1994) Using computer vision for food quality Evaluation. Food Technology, 48(6), 151–154.