Quality inspection of cookies using computer vision

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ABSTRACT

Product appearance plays a vital role in making a purchase decision. Colour, size and shape are significant factors that influence purchase decision of bakery products. Food shape is often closely regarded as its quality. Broken or deformed product may taste the same as an undamaged ones, but customers are reluctant to buy seemingly damaged goods. Due to the demands of high quality foods, automated food shape inspection has become an important need for the food industry. Computer vision provides one alternative for an automated, non-destructive and cost-effective technique to accomplish these requirements. Features such as the internal and external appearance contribute to the overall impression of the products quality. Consequently such characteristics have been evaluated by computer vision. The objective of this paper is to summarize and evaluate shape descriptors which can be used as indicators for quality of final product, and also as additional parameter for estimating end of baking process.

Keywords: computer vision, food quality, shape descriptors

INTRODUCTION

Computer vision systems are being used increasingly in the food industry for quality assurance purposes. Essentially, such systems replace human inspectors for the evaluation of a variety of quality attributes of raw and prepared foods. In food industry computer vision can be use for defect detection, dimensional measurement, and orientation detection, grading, sorting and counting 1,2.

Generally, computer vision system are comprised of image acquisition device with lighting system, storage system and digital computer with appropriate software for image segmentation, feature extraction and analysis. Features are parts of image with specific information about product and are described by colour, shape, size and texture1. Shape of baked cookies is important parameter of quality as consumers expects that all cookies have uniform shape and size. There are many shape descriptors available in literature, they are mainly categorised in two categories: contour-based shape descriptors and region-based shape descriptors 3,4. Overview and classification of shape descriptors can be visualised as displayed in Figure 1.

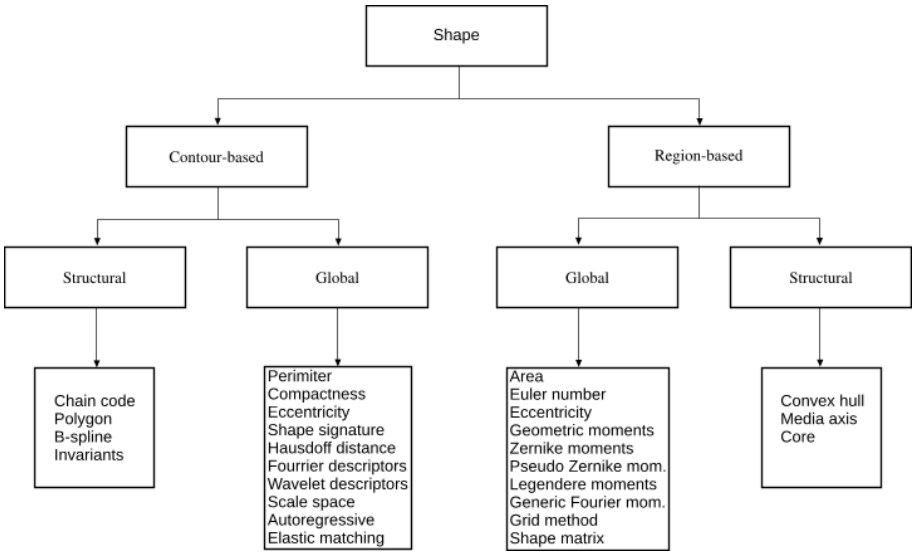

Figure 1. Classification and overview of shape descriptors

Two kinds of information are contained in each pixel, i.e. brightness value and locations in the coordinates that are assigned to the images. Brightness value is the colour feature while information of locations of pixel is known as size or shape features. Three commonly used features for size measurement of an object can be found for food quality evaluation: area, perimeter, and length and width. Compared with other features such as colour and texture, shape is easier to measure using image processing techniques.

MATERIAL AND METHODS

The cookies were prepared according to standard AACC (American Association of Cereal Chemists) formulation. It was used standard flour for production of cookies with three different moisture content (standard, S, with 16 g water/225 g of flour, dry, D, with 12 g water/225 g of flour and wet, W, with 20 g water/225 g of flour). Investigation was conducted on 33 samples during 10 minutes of baking. Cookies were baked at 205 °C and temperature was measured in the middle of samples which were thick 60 mm and high 7 mm.

Computer vision system includes image capturing device (EPSON™ Perfection V500 Photo), personal computer with EPSON software. Image processing has been done in ImageJ5 and Python with some libraries (Numpy, SciPy, OpenCV) which are all open

source programs. Acquired images first were thresholded in ImageJ and converted to 8-bit binary images (black and white). Using macro option, measurements of area, perimeter, Feret's diameter was determined for all samples (images). Python script has been written for measurements of sample height at specific points from sample centre axis.

RESULTS AND DISCUSSION

Result of analysis conducted with ImageJ, determination of classical image descriptors (area, perimeter, Feret's diameter,…), showed that during baking, first there is increase in cookie size (height and width) which results in increase of area and therefore perimeter (Figure 1), After that, there is slight decrease in observed quantities which is in compliance with baking dynamics (heat and mass transfer). Observed oscillations in Figure 1 can be explained through cookies deformation during baking and manipulation.

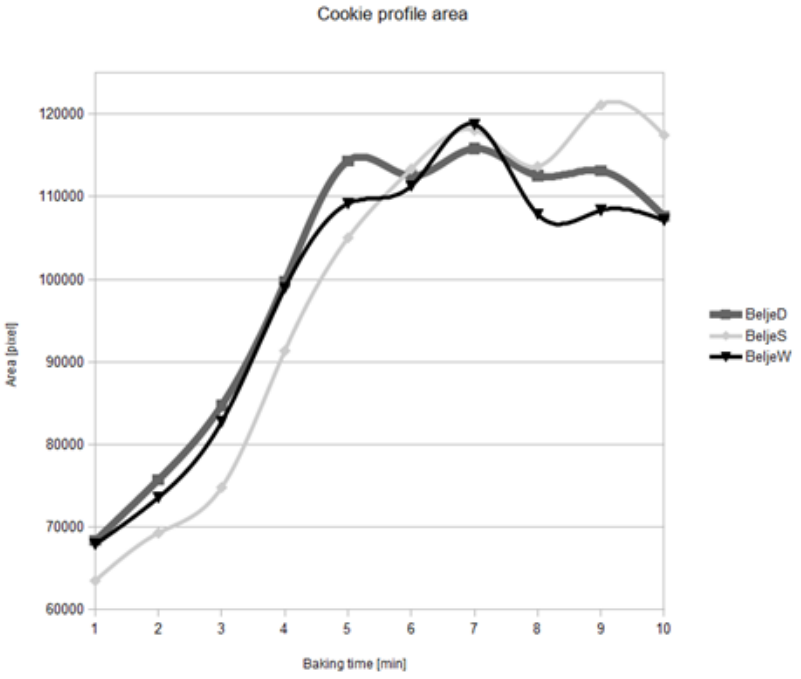

Figure 2. Cookie cross section area in pixels during baking

Feret's diameters provided information about maximum width and maximum height of cookies, which is useful for cookie shape description. Other parameters do not provide easy understandable information about cookies shape. More usable information is obtained from height profiles during baking (Figure 3, Figure 4) which contains information about cookies symmetry around vertical centre axis which is at 425 pixels.

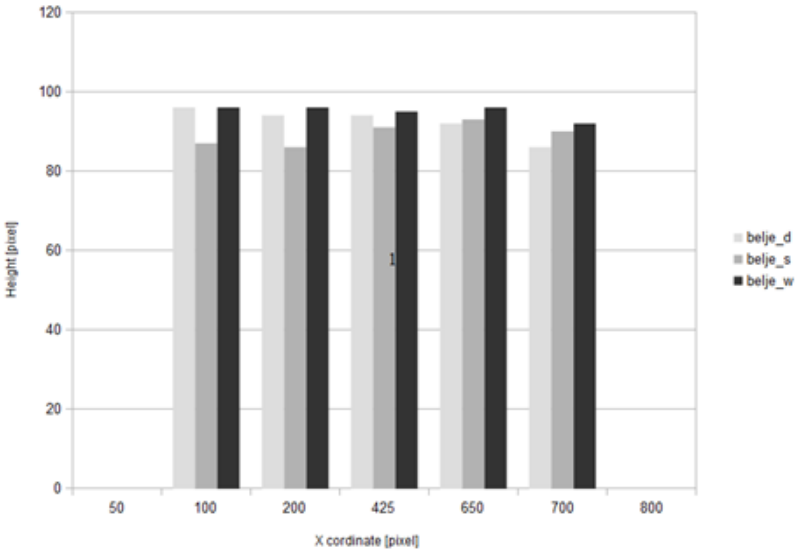

Figure 3. Cookies height profiles after 1 minute of baking

Profile is obtained by measuring heights at equal distances from centre axes to left and right. Distances have been chosen with respect to image size (850*200 pixels), and were: 0, 100, 200, 425 (middle), 650, 750, 800 pixels. Symmetry can be easily calculated as difference of equally distant heights from cookie centre.

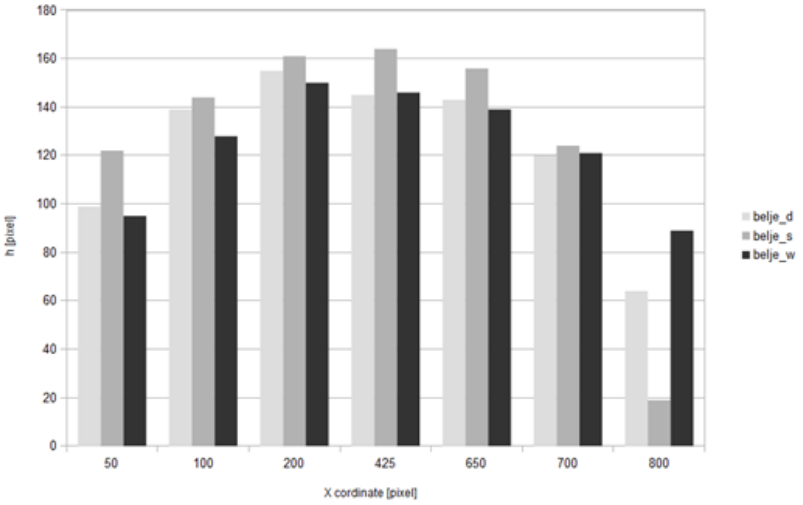

Figure 4. Cookies height profiles after 10 minute of baking

CONCLUSIONS

According to results of size (width and height) and shape deformation of cookies during baking process, computer vision can be applied to inspect shape of final product and in combination with other process parameters better define the end of baking process. We believe that the proposed framework opens up new possibilities for dynamic visual inspection of cookies during baking (i.e. inspection texture and colour) with aim of better process control.

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