Queensland University of Technology
Brisbane Australia

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Senadeera, Wijitha & Banks, Jasmine (2011) Analysis of micro-structural changes and measurement of their parameters of a food material. In Alves-Filho, Odilio, Eikevik, Trygve, & Alves, Svetlana (Eds.) *Proceedings of the 5th Nordic Drying Conference (NDC 2011)*, Norwegian University of Science and Technology, Aalto University and the Norwegian University of Science and Technology, Helsinki.

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ANALYSIS OF MICRO-STRUCTURAL CHANGES AND MEASUREMENT OF THEIR PARAMETERS OF A FOOD MATERIAL

W. Senadeera, J. Banks

School of Engineering Systems
Queensland university of Technology
Brisbane QLD 4001
Australia
Phone: +61 7 3138 6887
Fax: +61 07 3138 1469
email: w3.senadeera@qut.edu.au

Keywords: dehydration, rehydration, microstructure, image analysis

ABSTRACT

Food microstructure represents the way their elements arrangement and their interaction. Researchers in this field benefit from identifying new methods of examination of the microstructure and analysing the images. Experiments were undertaken to study micro-structural changes of food material during drying. Micro-structural images were obtained for potato samples of cubical shape at different moisture contents during drying using scanning electron microscopy. Physical parameters such as cell wall perimeter, and area were calculated using an image identification algorithm, based on edge detection and morphological operators. The algorithm was developed using Matlab.

INTRODUCTION

Rate of dehydration/rehydration are important quality parameters for dried products. Theoretically, if there are no adverse effects on the integrity of the tissue structure, it should absorb the water to the same moisture content as the initial product before drying. However, the nature of internal porous structure, and mechanical and elastic properties of the dried material, will influence the moisture uptake during rehydration. During these processes different microstructure can be obtained showing changes to the cell structure (Senadeera, 2000).

Computer vision includes the capturing, processing and analysing images, facilitating the objective and non destructive assessment of visual quality characteristics in food products (Timmermans, 1998).

Enhancement of the image is a tedious procedure. If the cell is to be cropped out of the image, it had to do so using certain features such as the cell walls. To do that, the image contrast had to be manipulated so that only the cell boundaries remain. The first step is to brighten up the image to bring out the less obvious details. Among all the contrast manipulation techniques, histogram equalization is the most popular method (Rafael et al., 2004).

At this stage, the edges of the cells are needed to crop out the cell image. To do this, the threshold process of the image will render pixels with certain levels of contrast intensity white while leaving the rest black and morphological operators will be used to clear out the rest of the unwanted pixels such as starch cells (Russ, 2002).

Current methods in using image processing for identifying unique parameters in sample images are done using the pixels of the image, but not in engineering terms. Therefore this project will attempt to accomplish the same but using engineering algorithms.

Using potato cells as a sample, this project will attempt to visualize the two-dimensional cell image in a three dimensional form and calculate the area and circumference of cells from a normal potato sample, a dehydrated sample and a rehydrated sample. The samples has been gold-dusted beforehand as the sample pictures were taken using an electronic microscope, which require metals to be present so that a clear picture of the microscopic structure can be taken. After averaging the area and circumference of almost all the cells in the sample image, it is then compared to other sample images in a plot form to determine the effects of dehydration and rehydration on a potato cell.

Aims of this proposed project are, study micro structural changes during dehydration and rehydration of a food material and develop an image identification to detect cell parameters. Current methods in image processing for identifying unique parameters in sample images are done using the pixels of the image, but not in engineering terms. Therefore this project will attempt to accomplish the same but using engineering algorithms.

MATERIALS AND METHODS

Raw material

Potato was used as the food material. Potato was selected to cover the broader range of food materials. They were cut into 1 cm cubes and used for dehydration in a convective laboratory dryer.

Experimental conditions

Dehydration of fresh potato cubes at the temperature of 50^{o}C. Samples were taken at 1 hour intervals for moisture measurement and microscopy measurements. Final dehydrated samples were used for rehydration at room temperature. Samples were collected at hourly intervals for moisture measurements and microscopy.

Microscopy

Scanning electron microscope was used to image analysis of the samples. Samples were dehydrated prior to examination and covered with a conductive coating.

Image analysis

Matlab was used for the image analysis process. Formulation of an image identification algorithm to characterize physical parameters such as cell wall perimeter, and area are based on edge detection and morphological operators and represent the cells as three dimensional objects.

RESULTS AND DISCUSSION

Process cell detection

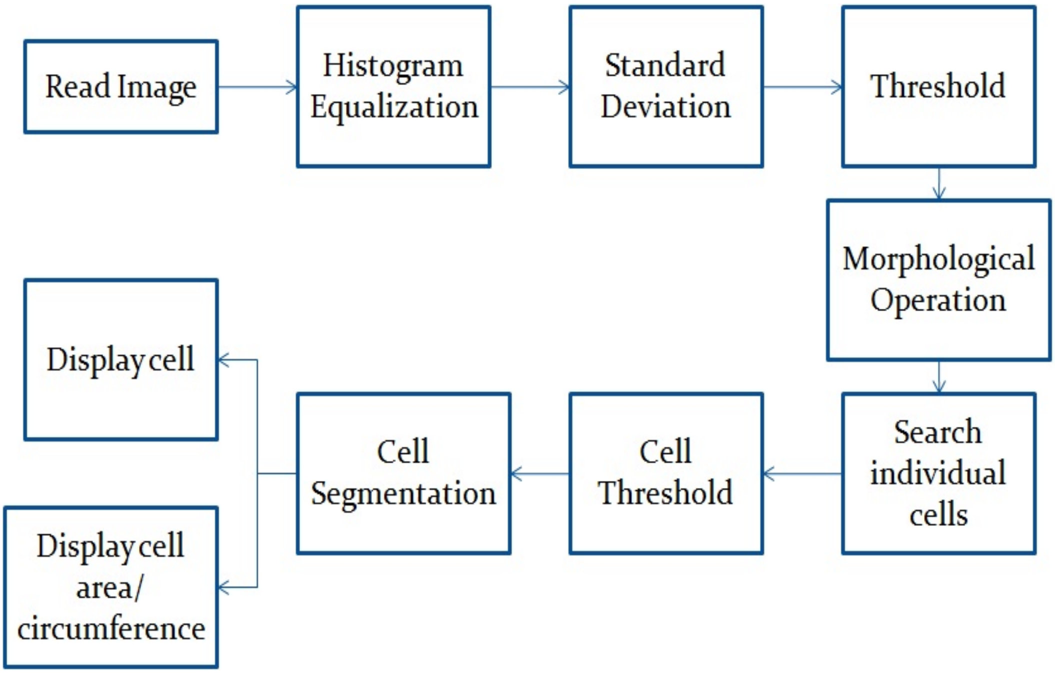

Figure 1. Process of Cell Detection

The steps involved in the cell detection process are shown in Figure 1. After the image is read in, histogram equalisation is used to enhance the contrast. The standard deviation of a square neighbourhood of pixels at each point in the image is then calculated. The standard deviation image is then thresholded to identify locations having a high standard deviation score. It is considered that a high standard deviation of pixel values in the image will correlate with features of interest, such as cell edges.

The thresholding method used makes use of two threshold values, T1 and T2, where T1 > T2. Pixels in the thresholded image with variance scores greater than T1 are immediately set to 1. Pixels with variance scores greater than T2 are set to 1, only if they are adjacent to a pixel already set to 1. All other pixels in the thresholded image are set to 0. The process is applied iteratively to until there is no further change in the thresholded image.

The next stage of the detection process involves applying morphological opening and closing to the thresholded image. Opening is used to remove small regions, not connected to a boundary, while closing is used to fill small holes. Next, large enclosed regions in the thresholded image are chosen as likely candidates for cells. Once the cell region is estimated, the area and perimeter are also calculated. An example of the resulting images at each step of the process is shown in Figure 2.

Figure 3(a) shows the original image, masked with the selected cell region of Figure 2(f). In Figure 3(b), the cell region is shown using 3-D visualisation, where the height is proportional to their pixel's grey value.

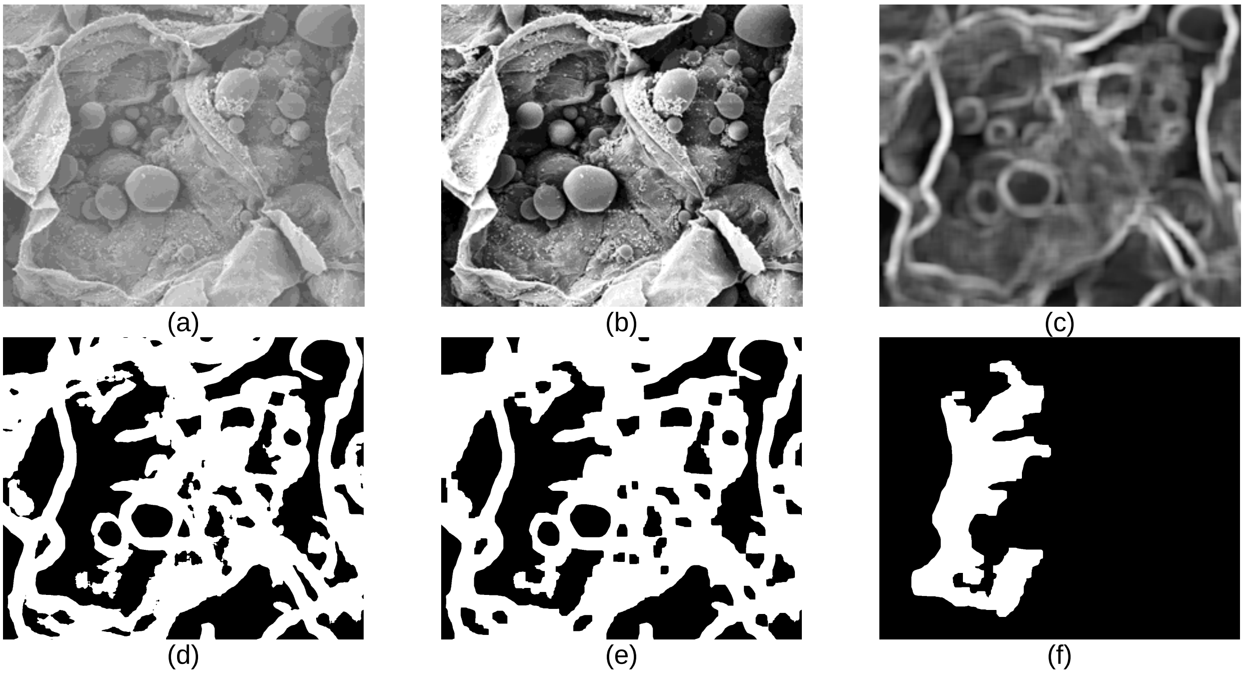

Figure 2: (a) portion of original image, (b) histogram equalised image, (c) standard deviation image, (d),thresholded image (e) thresholded image after opening and closing, (f) selected region.

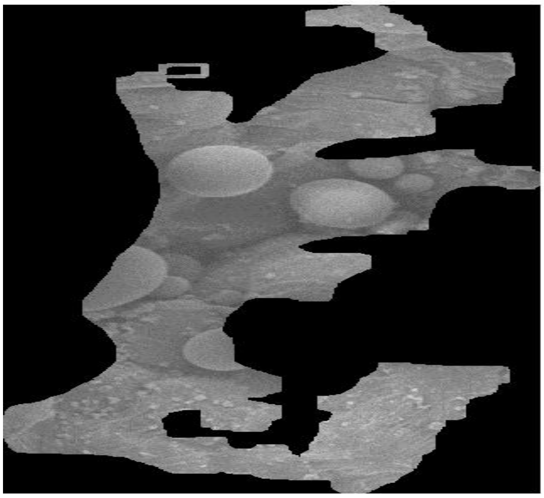

Figure 3 (a). Masked cell

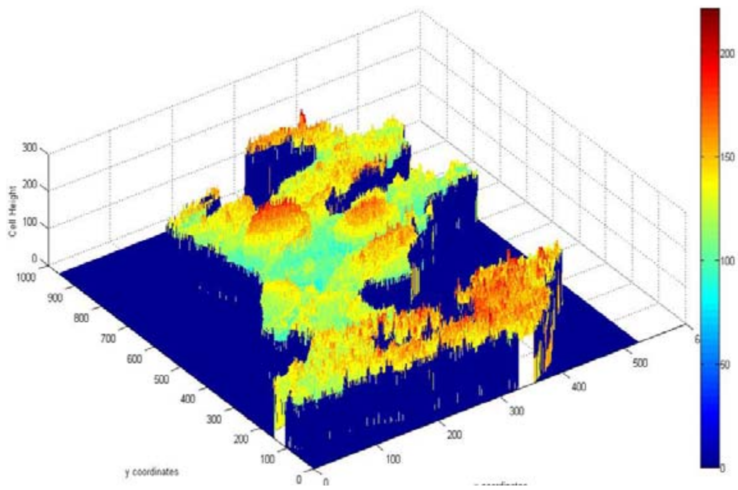

Figure 3 (b). Chosen cell 3-D view

Using this process, average values of area and perimeter were calculated for images at each stage of the dehydration process. Graphs of the calculated areas and perimeters are shown in Figure 4.

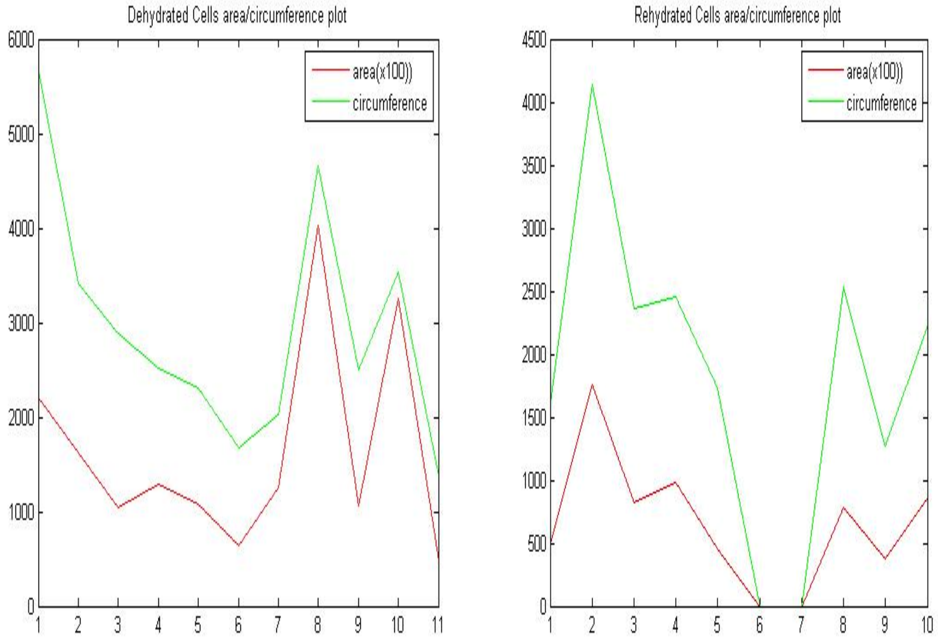

Figure 4. Calculated areas and perimeters in dehydration/rehydration

It can be seen that even though the development of this algorithm is in its preliminary stages, that for the first six images, there is a trend of area and perimeter both decreasing as the dehydration process progresses. In images 7 and 10, the area and perimeter both increase. It is possible that the cells tend to open up again as dehydration progresses past this point, or it is possible that the image segmentation algorithm has not worked as well for these images.

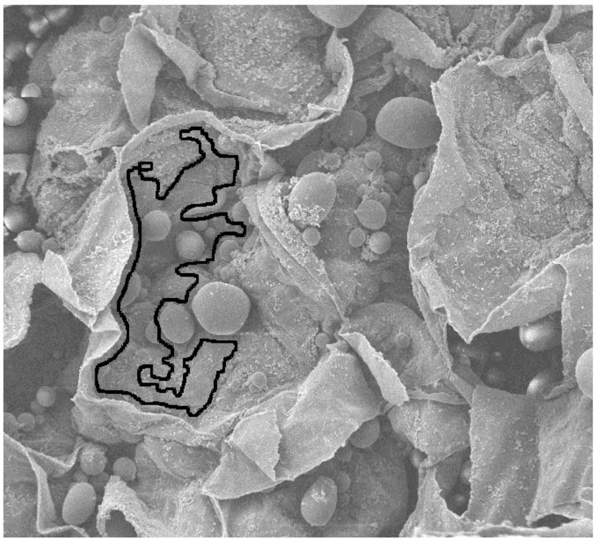

Figure 5. Segmented cell superimposed on the original image

The segmented cell region superimposed on the original image is shown in Figure 5. It can be seen that this does not exactly follow the cell boundary as desired. Further work is being done on an improved algorithm to localise cell boundaries. This will result in a better estimate of average area and perimeter of cells, as dehydration takes place.

CONCLUSIONS

This study showed that the cellular pysical parameters are similar to those reported in the literature. Further work is needed to improve the algorithm to localise boundaries. Also future work is needed to construct microstructural models accounting for during dehydration and rehydration and correlate thair parmaeters to the drying conditions.

NOTATIONS

T1, T2	threshold values

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