МАТЕМАТИЧЕСКИ МОДЕЛИ НА РАКОВИ ОБРАЗУВАНИЯ НА ГЪРДАТА ОТ РЕАЛНИ ИЗОБРАЖЕНИЯ ОТ КОМПЮТЪР ТОМОГРАФ: ПРЕДВАРИТЕЛНИ РЕЗУЛТАТИ

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COMPUTATIONAL BREAST CANCER MODELS CREATED FROM PATIENT SPECIFIC CT IMAGES: PRELIMINARY RESULTS

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Abstract: Breast cancer remains the most common cause of death for women below seventy years of age. Although, screening nowadays is a common practice the standard tools for such procedure in some cases of breast cancers are not as efficient as desired. New approaches are constantly being developed to detect and diagnose the cancerous formations as earlier as possible. These new techniques require extensive optimization of parameters which is best performed with computer-based models. Our main objective is the creation of comprehensive breast cancer computer database for the purposes of developing, testing and optimizing new x-ray imaging techniques. This paper reports on a semi-automatic approach for segmentation of cancerous tissue extracted from patient specific CT datasets and the creation of solid breast cancer models.

Key words: breast cancer, computer-based breast cancer models, patient CT images, segmentation

INTRODUCTION

Breast cancer is the leading cause of death for women below seventy years of age. In Europe, one [illegible] as a critical [illegible] reast cancer screening is the digital mammography. However, screening and diagnosing cancers hidden in breast dense parenchyma with digital mammography remains a challenging task. Approximately 10% to 20% of palpable breast cancers are still not visible in planar mammograms due to insufficient soft tissue contrast and the effect of overlying structures in this modality [1]. New approaches to breast imaging are continuously under development. Breast tomosynthesis is one such approach. This technique is able to produce three-dimensional (3D) structural information of the breast in which the influence of overlapping tissues is greatly reduced and the accuracy of cancer detection is increased, particularly for breast masses [2]. Another approach is the breast CT [3]. The introduction of these techniques for routine screening mammography requires optimisation of parameters and algorithms, which process is best carried out by using computer models.

Our long term goal is to create a computer database with breast cancer models for the purposes of studies of new x-ray imaging techniques applied to breast. The main contribution to this aim is to develop segmentation algorithms for breast masses with irregular shapes from patient specific data. This paper presents a semi-automatic algorithm for segmentation of cancerous tissues from CT patient images.

CT IMAGES

Two sets of abdominal CT images were obtained at the University Hospital "Saint Marina" in Varna, using SOMATOM (Siemens). The acquisition was made by utilizing a standard protocol that provides images of size 512 x 512, 16 bits grey level resolution. For convenience further on in this paper the two sets of CT images are referred as S1 and S2. The thickness of the slices is 3mm for both cases, while the number of slices is 177 and 134 for S1 and S2, respectively. The images are with square pixel size of 0.9766 mm for S1 and 1.2695 mm for S2.

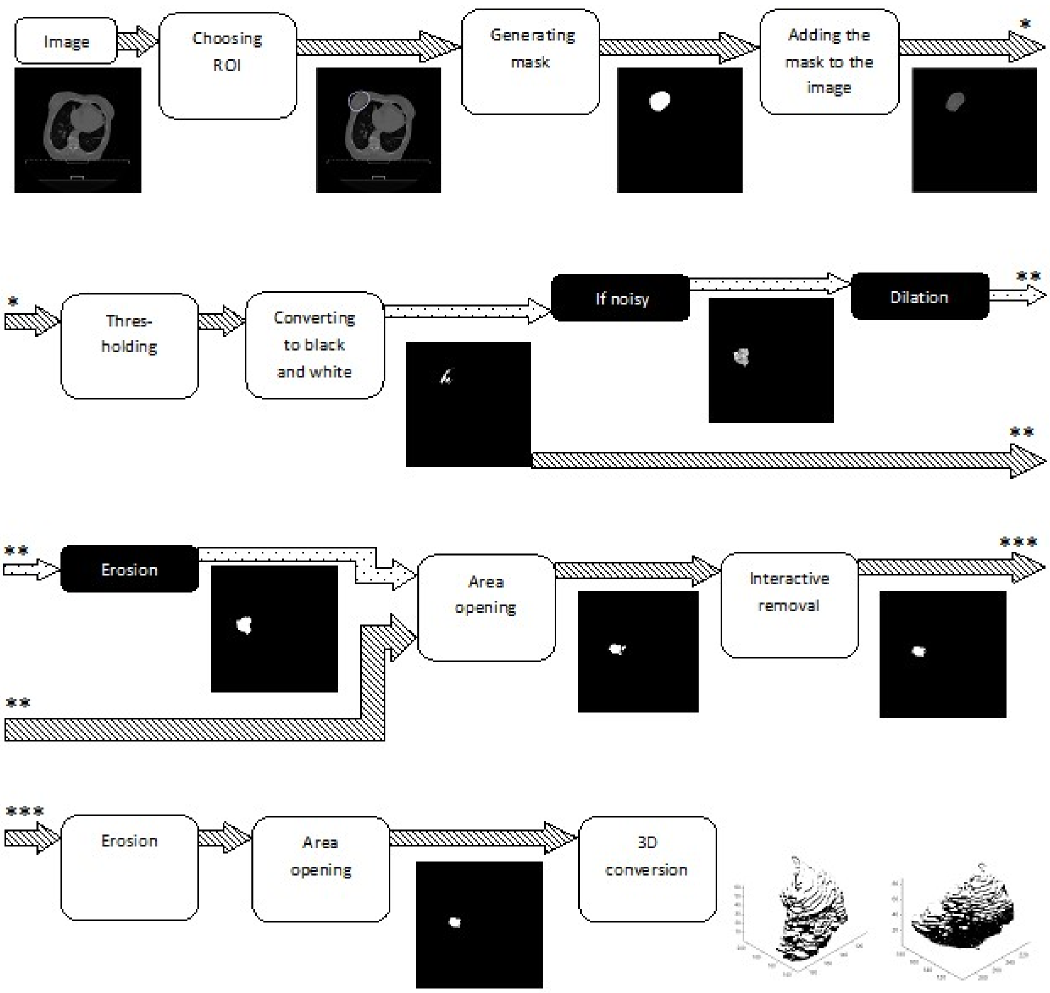

Fig. 1. Block diagram of the algorithm for breast cancer segmentation.

The findings on the CT images were classified as malignant tumors by an experienced radiologist who works in this area. The two cancer formations are characterized with different size and location within the breast. Specifically, twenty-two slices were found to contain information about the malignant tumor formation in S1 and thirty CT images in S2. All images were anonymized prior processing.

SEGMENTATION ALGORITHM

The obtained DICOM images were processed to leave only the information about the breast cancer by applying an in-house developed algorithm for semi-automatic segmentation. The main stages of the proposed algorithm are shown in Fig.1, where CT images correspond to slices taken at different location in the patient CT scan.

Initially, a region of interest (ROI) is selected for each of the slices, in order to reduce the size of the segmented area and therefore to improve the efficiency of the proposed segmentation algorithm. From the selected ROI, a binary mask is generated, where the values of the pixels inside the ROI are set to ones and values of the pixels outside the ROI to zeros. The generated masks are then applied to the slices from the CT sets which results into the desired area subjected to segmentation. Consequently, the preprocessed CT images were subjected to image thresholding. The threshold value was chosen based on an in-house developed adaptive thresholding algorithm. Thresholding is a necessary process, which results in rough segmentation of the cancerous tissue. Further on, the CT images were converted to binary images on a pixel by pixel basis, as the values of the pixels which do not belong to the breast cancer were set to zero, while these which belong to the cancerous tissue were set to one. Although S1 responded well to this technique the case of S2 proved more challenging. Due to the increased image noise in the images from set S2, the segmented final cancer volume did not appear solid. This issue opted for a multiple iterations of the morphological operation dilation followed by an erosion operation, both performed with a small sized diamond-shaped structuring element. These operations correct the existing imperfections caused by the noise while maintaining the shape of the segmented objects (Fig.2).

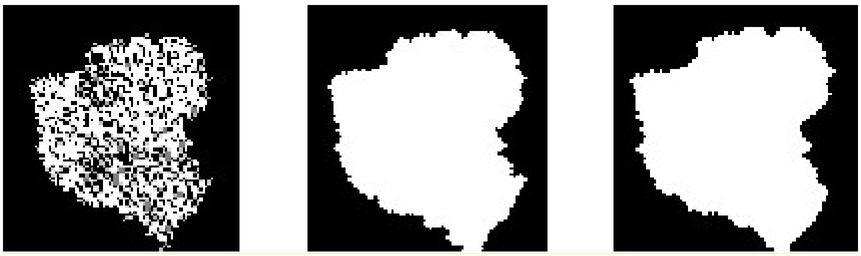

Fig. 2. Originally segmented image, dilated image, eroded image
(from left to right).

However, often in the different slices, for both image sets, objects not containing cancer information were segmented to belong to cancerous tissue. For convenience, these objects are referred as artefacts. To lower the need of interactively removing artefacts, a series of image processing operations were applied to the already segmented images (in binary form).

In order to remove smaller artefacts morphological area opening was applied to each slice, where objects with a given maximum number of pixels were excluded. In the case of S1, objects with fewer than 50 pixels seemed appropriate for removal. Nonetheless, attention should be paid to the parameters of the area opening operation as cancer information could be lost due to its size in some slices. Such is the case of S2, where in order to preserve information about the malignant formation, objects with no more than 5 pixels were removed.

Finally, morphological erosion with a diamond-shaped structuring element was performed on each slice followed again by a morphological area opening to eliminate any remaining artefacts.

The segmented volumes are then stored in a 3D matrix. Post-processing of the 3D models includes the application of different 3D filters which results in smoothing the edges of the voxelized computational cancer model (Fig.3), as well as interpolation techniques to scale properly the final model.

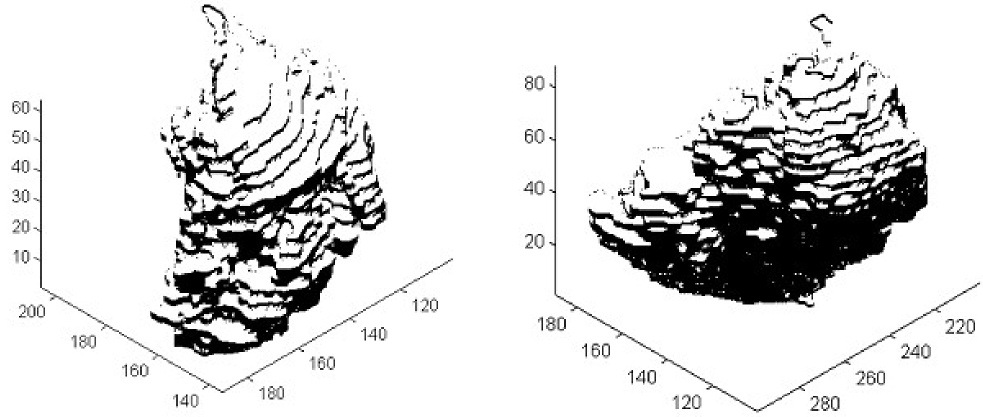

Fig. 3. 3D models of the segmented malignant tumor formations from S1 and S2.

EVALUATION

An experienced radiologist evaluated the realism of the new computational breast cancer models. The created computational based breast cancer models were stored in a database with detail information for the size, the origin and the description given by the pathologists. The subjective evaluation showed satisfactory realism of the generated 3D computational models.

CONCLUSION

This paper presented preliminary results of the development and application of an algorithm for segmentation of breast cancers from patient specific CT images. Next is to create more computational models of breast cancers, which will be used as a base for the modelling of realistic mathematical models of breast cancers. The achieved results, which apart from applications in 3D breast imaging research, are also encouraging for educational and training purposes.

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