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Review Article

Simplification of breast deformation modelling to support breast cancer treatment planning

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ABSTRACT

The exact delineation of tumour boundaries is of utmost importance in the planning of cancer therapy, either surgery or pre- or post-operative radiation treatment. In the case of breast cancer one of the most advanced modalities is magnetic resonance imaging (MRI). Although MRI scans provide wealth of information about the structure of a tumour and the surrounding tissues, the data obtained represent the patient in a prone position, with breast, in a coil while surgery is performed in a supine position, on lying breast. There is no doubt that a patient's breast in both positions has a different shape and that this influences the intra-breast relations. Our present preliminary study introduces a simple breast model developed from prone images. The model should be built rapidly and by a simple procedure, based only on essential structures, and the goal is to prove its usefulness in treatment planning.

1. Introduction

Recent studies show that breast cancer is the most frequent women's cancer around the world. According to WHO's report GLOBOCAN 2012 [1]a constantly growing incidence is observed since 1975 across all woman's age groups (20–80). Consequently, diagnosis needs to be precise and fast, whereas treatment needs to be as much personalised as possible.

The most precise examination, in which tissue images are obtained with high resolution, is magnetic resonance imaging (MRI). Images from MRI examinations contain information about breast tissue structures, both shape and physical properties. MRI data offers information about tissue conditions that can not be obtained by other popular imaging techniques, such as mammography, ultrasound or computed tomography [2]. The most precise examination, in which tissue images are obtained with high resolution, is magnetic resonance imaging (MRI). Images from MRI examinations contain information about breast tissue structures, both shape and physical properties. MRI data offers information about tissue conditions that can not be obtained by other popular imaging techniques,

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such as mammography, ultrasound or computed tomography. The bigger the breast, the more its shape differs in each position [2]. Consequently, sometimes the lack of proper tumour delineation leads to mastectomy and causes significant functional deterioration of patient status. An alternative is a partial, breast preserving wide tumour excision, sometimes supported by oncoplastic procedures of tissue displacement. In this case only the tumour and the surrounding tissues are removed. However, in this case, the region of interest must be precisely determined. Consequently, the need arises to easily convert MRI data to the position of the patient during surgery/ radiation therapy which would facilitate the safe and efficient flow of these procedures. This cannot be obtained by placing the patient in a supine position for MRI nor in a prone position during surgery, and therefore the only way to achieve this goal is by computer image processing. A similar problem was addressed in [3], where mammogram compression was simulated based on a simple breast model. MRI image deformation was discussed in [4], but the model presented was very complex regarding breast tissues. In recent studies [5,6] models that consist of four structures: fat, glandular, cancerous and skin tissues are considered. Building a model for each patient with such complex structure, extend significantly computation time and the same, time of diagnosis.

One way to simplify models could be reached by taking into account that the parameters of fat tissues have a much greater influence on deformation than those of fibroglandular tissues [7]. Moreover, experimental data suggested that tumour stiffness has a minimal effect on breast deformation [7]. It is also observed, that with age, fibroglandular tissue volume shrinks compared to fat tissue [8]. Another simplification [9], is to model skin and fat as one material with the same properties. To our knowledge, the above simplifications were never applied in one model.

In this work we present a basic concept for a model of a breast and its deformation, paying special attention to its further use in clinical practice. Our study consists of creating a breast model which transforms prone MRI images as fast as possible into a supine plane and its comparing the results with supine images, to prove the feasibility of this technique for surgical planning support.

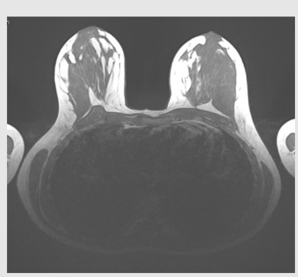
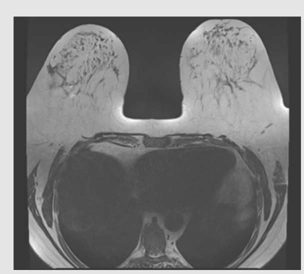
2. Material and methods

2.1. Data acquisition

Breast MRI data. MRI is widely used in medical diagnosis, in particular in breast imaging [10]. T1 and T2-weighted MRI scans were acquired at the Center of Oncology – Maria Sklodowska-Curie Memorial Institute, Branch in Gliwice, Poland on a Siemens scanner MAGNETOM Aera 1.5T. The data covered approximately 0.7 mm $\times$ 0.7 mm $\times$ 3 mm real volume per voxel. Examples of images are shown in Table 1.

Breast PET-CT data. Positron Emission Tomography with Computer Tomography (PET-CT) is a fusion of 3D X-ray structural examination (CT) with metabolic examination (PET) performed using fluorodeoxyglucose (FDG), an analogue of glucose, to indicate tissue metabolic activity. PET-CT scans were acquired at the Center of Oncology – Maria Sklodowska-Curie Memorial Institute, Branch in Gliwice, Poland on a Philips GeminiGXL 16 scanner. The data consisted of ca. 280 axial slices of patients in a supine position covering almost the whole body. The data covered approximately 1.17 mm $\times$ 1.17 mm $\times$ 3 mm real volume per voxel. PET-CT scans were obtained in a supine position and were used as a reference to validate the computed deformation. Examples of images are shown in Table 1.

Table 1 – Patient datasets.

	Patient 1	Patient 2
Age	29	64
Tumour diameter	1 cm	0.4 cm
MRI image		
PET-CT image