Breast Volume Measurement Using a Games Console Input Device

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Abstract. The automated measurement of breast volume has applications both in facilitating the decisions made by surgeons prior to breast reconstruction and in improving density estimation. We describe a novel approach to volume measurement for surgical planning, using a games console input device - the Microsoft Kinect. We have explored the ability of the device to measure surface depth for a range of distances and angles, demonstrating a mean depth error of below 1.5 mm for a distance range of interest (0.5 - 0.8 m). We have also validated the use of the system for volume measurement using a full-sized model female torso. The Kinect-based result is in good agreement with the volume measured by filling a mould of the breast with water (225.5± 8.7 ml, 229.4 ±9.7 ml respectively). The method has the potential to provide convenient, cost- and time-effective measurement of breast volume in clinical practice.

Keywords: breast volume, breast surgery, breast density, Microsoft Kinect.

1 Introduction

Measuring breast volume is crucial for planning breast surgery - whether to predict the cosmetic outcome or to choose an appropriate surgical strategy [1]. Knowledge of the shape and the volume of the breast can also contribute to more accurate assessment of breast density (measured as the proportion of dense glandular tissue in the breast volume). Nevertheless there is no standard method for

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measuring breast volume [2]. When measuring breast density, the use of two-dimensional mammographic images to derive volume measurement suffers from the ambiguity of estimating a three-dimensional (3D) shape from its planar representation [3]. Techniques used for surgical planning include anthropomorphic (anatomic) measurements, moulding, the Grossmann device and measurements based on Archimedes principle. None of these is well established clinically due to lack of reliability or inconvenience [1, 4]. More recent techniques like stereophotogrammetry (using a stereo camera array) [5], laser scanning [2] breast CT or MRI describe the 3D shape of the breast accurately but their use is restricted by high complexity and cost. Those automated or semi-automated methods use complex imaging equipment, which needs stationary installation, maintenance and trained staff. This paper proposes the use of a games console input device for automated measurement of breast volume.

It is aimed to provide a convenient, fast and inexpensive method that allows non-contact measurement and uses small, transportable equipment which is ready for use without time and labour intense installation and calibration. The definition of the region of interest, the portion of the breast for calculating the volume can be indicated by markings on the patients skin and is therefore flexible and adaptable to different tasks.

The Microsoft Kinect for Xbox 360 input device (Kinect) is a relatively cheap, small sensor based on infra-red light triangulation. It is an optical device, which projects a speckle pattern onto a scene within its field of view and evaluates how this pattern is distorted by the objects in the scene. By comparing the original to the distorted pattern it measures the location and shape of objects without contact, working at ambient indoor light conditions [6]. It was originally designed for computer gaming and human interaction in a virtual environment, but has found wide application in research including medical applications such as patient size measurement [7] and respiratory motion tracking [8]. Recently published papers have demonstrated the feasibility of using the Kinect for breast imaging. In one application, two Kinect sensors were used to map the breast surface [9, 10] whereas others use a single Kinect to assess the aesthetic aspects of breast-conserving cancer treatment [11] or breast surgery in general [12].

2 Methods

The Kinect sensor has two outputs: a depth image, generated with the help of laser triangulation and an RGB image of the field of view. The depth image is presented as a cloud of points representing the location of objects within the sensor field of view. All experiments were performed using the KinectFusion mode, which sums multiple frames and combines them independently of sensor movement [13]. This mode was chosen as the field of view of the sensor can be enlarged and parts of the breast, which can not be evaluated in a "single shot" can be resolved by slow movement of the sensor. Also blank spots in the depth image e.g. due to reflection can be covered by a slightly different viewing angle.

In the following section two experiments are described. A feasibility study evaluating the suitability of the sensor using a simple index card model was