# GEOMETRIC UNWARPING FOR DIGITAL SUBTRACTION MAMMOGRAPHY

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**ABSTRACT**

Three dimensional (3D) mammograms taken some time apart could be subtracted to bring out changes that might be due to growing breast carcinomas. A geometric unwarping method for digital subtraction mammography is presented. This procedure is tested on simulated, warped 2D images. Experimental results and performance evaluations are given. We conclude that local registration methods are sufficiently more accurate than the global methods to warrant their increased programming complexity and computing time. Several aspects of image registration which need further investigation and improvement are also discussed.

**KEYWORDS** - Geometric unwarping, Triangulation, Triangular interpolant, Digital subtraction mammography.

## I. Introduction

Breast cancer is approaching an epidemic rate of 1 out of every 10 women [1]. The means to prevent breast cancer has not yet been found. Detection and treatment of breast cancer at early stages is the only method with proven potential for lowering the death rate from this disease. If smaller tumors could be detected than is now possible by standard mammography, many more lives could be saved. New technologies, such as computed tomography (CT), magnetic resonance imaging (MRI), digital subtraction angiography (DSA), transillumination scanning, and ultrasound offer a wide selection for breast imaging [2]. None of these procedures are, however, expected to replace two dimensional, projection mammography as the first-line imaging technique for the detection and diagnosis of breast cancer, in their present forms [3]. Improving breast imaging modalities is understandably a great challenge to diagnostic radiology.

Breast tissue is soft, flexible, and changes shape over time. Contrast between soft tissues of the breast is inherently low and relatively minor changes in mammary structure can signify the presence of a malignant breast tumor. Two three-dimensional x-ray mammograms taken some time apart, e.g., at annual mammographic screenings, could be subtracted to bring out changes that might be due to a growing breast carcinoma [4]. Because of the differences in patient positioning, breast compression, dose parameter settings, change of equipment, etc., the difference image of two mammograms may contain considerable false contrast due to misregistration. Thus a geometric operation has to be performed to match several corresponding features in the 3D mammograms prior to subtraction. Therefore, it is necessary to first find the 3D transformation or "geometric warping" that relates an earlier 3D mammogram of a breast to a current 3D mammogram. (We will leave the production of 3D mammograms to future reports.)

If a sufficient number of corresponding features or "control points" in the 3D mammograms could be determined, then the mammograms could be accurately registered over their whole extent. Control points, i.e., features which are visible or can be defined unambiguously, and whose coordinates can be determined in both 3D mammograms, could then be used to drive the geometric unwarping algorithms. This paper will address optimal interpolation and extrapolation from the control points. The selection of control points and optimal pixel density interpolation algorithms will be covered in later papers.

The 2D image registration problem can be stated as follows: Given the coordinates for N pairs of control points in two images of the same scene, $\{(x_i,y_i),(u_i,v_i),\ i = 1, 2,\ldots,N\}$, determine the geometric unwarping functions

$$x = x(u,v)$$
$$y = y(u,v)$$

that will register the images. We will refer to the image with coordinates (x,y) as the reference image and the image with coordinates (u,v) as the warped image. Once the coordinates of all pixels in the warped image are determined, we apply an appropriate interpolation procedure to its density function. We thus obtain an image whose geometric coordinates are registered, an unwarped image. Then further digital manipulations, such as digital subtraction