3D Reconstruction Based on Registration of Interpolated Curved Slices

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Abstract

Three dimension models are created from randomly dispersed data and from an incorrect positioned data of two dimensional images play an important role in medical image processing. The shape of an individual organ is very much essential for diagnosis or to plan for surgery and also it is necessary for Visualization. The large gaps between the two dimensional image slices and incorrect position between these slices makes more complicated and also challenging factors in envision and evaluation of the dataset for each slice. The elimination of these two problems requires interpolation and registration techniques. This paper presents a Deterministic method of Linear Interpolation by using Curvature based Image Registration of level set technique. From this proposed method a misplaced slice is computed and interpolate between two existing slices using displacement field factor. Finally the Three Dimensional model is reconstructed from these interpolated slices. Experimental result shows the effectiveness of the proposed method by reconstructing three dimensional models.

Keywords - Deterministic method of linear interpolation, Curvature based Image registration, Medical image Vision, Medical image Analysis, Reconstruction of 3D model.

1. Introduction

Image interpolation is an important factor in visualization and analysis of medical images. Interpolation is the process of determining the values of a function at particular positions lying between its samples. It is achieved by fitting a continuous function through the discrete input samples [11]. This permits input values to be evaluated at arbitrary positions in the input. From image processing [1][5], it is not only interested in analyzing an image but it also comparing the images in order to combine information or to track changes. For this reason two important tasks such as image registration and image interpolation are needed in image processing applications.

Image Registration is the determination of a geometrical transformation that aligns points in one view of a model with corresponding points in another view of the same model. Whereas the Interpolation is the process of determining the values of a function at particular positions lying between its samples.

Significantly, in medical image processing applications [5], the non-invasive imaging is mainly used in almost all stages of patient care from disease detection to treatment guidance and monitoring. And also especially in medical image modalities such as CT or MRI etc., a sequence of two dimensional slices are used in constructing three dimensional model. During reconstruction process the presence of large gaps between the two dimensional image slices that makes up a dataset for each slice, and misalignment between these slices are the two important problems in three dimensional models. These gaps and miss-alignments make more complicated and challenging

Factors in visualizing and analyzing the data. This generates the problems of discontinuity in structures of three dimensional reconstructed models. Hence it requires interpolation and registration techniques to reconstituting the complete and accurate three dimensional models [10] by eliminating the above problems.

This paper presents a deterministic method of linear interpolation for two dimensional slice interpolation using curve based image registration of level set technique. In registration method a displacement field is used to compute the corresponding points in linear movement between the slice, and the in between slice is interpolated using a simple averaging of the registration results. The details of the proposed method is given in Section 2, some experimental results of the proposed method is given in Section 3. The conclusion is given in Section 4.

2. Proposed Methodology

Consider two 2D image slices in the form of IS₁ and IS₂, for image slice registration [2] is to find a spatial transformation such that the transformed IS₂ image slice matches the IS₁ image slice, subject to a suitable distance measure in the form of forward registration [8]. The goal of registration is to matching the set of image gray values between two image slices. This transformation is a simple translation to more sophisticated non-rigid free form of deformations. Most of these forms are formulated in terms of a variational approach, using the joint function, it is given as follows [8][9]:

\[ J(u) = D[IS₁, IS₂; u] + \alpha RS[u], \]

(1)

Where in eq.(1) ‘D’ represents a distance measure (external force) and ‘RS’ represents the rate of smoothness of ‘u’ (internal force). The parameter ‘\( \alpha \)’ is used to balance the two terms. In this functional, ‘u’ should be found, such that the joint functional is minimized. This model is called single direction model because the IS₁ image slice is fixed and only the IS₂ image slice is moving. This makes asymmetry in the results in such a way that if we fix the IS₂ image and move the IS₁ image and it should match with the IS₂ image (backward registration), the result may not be exactly opposite to that of the forward registration. so, change this model in the context of image slice interploation on by changing the formulation to the following: \( J[u] = D[IS₁(x - u), IS₂(x + u)] + \alpha RS[u], \)

(2)

Where in eq.(2) IS₁, IS₂ are bounded in the domain: \( \Omega \rightarrow \mathbb{R}^d \) where ‘R’ is Euclidean space and ‘d’ describes the spatial dimension of the images, and provided as input \( \Omega = [0,1]^d \) is the domain of images, ‘x’ is the grid of image values and ‘u’ is the displacement values for each grid point. ‘\( \alpha \)’ is the regularization constant and ‘RS’ is the regularization term.

Assume that the image slice to be interpolated [7][12][13], denoted by ‘IS’ drawn in red color, and is in the middle of the two given image slices. If ‘IS’ is an arbitrary image slice between two image slices of IS₁ and IS₂, then the distance is computed from image slice ‘IS’ to image slice ‘IS₁’ and image slice ‘IS₂’, it is denoted by ‘d₁’ and ‘d₂’ respectively is as shown pictorially in figure 1 and interpolation of Image slice in 3D is shown in figure 2.

\[ IS \]

Fig 1: Pictorial representation of interpolation of slice

Then the ration is calculated by \( r = d₁/(d₁+ d₂) \), and the equation (2) should be considered for interpolating image slice ‘IS’:

Equation (2) is considered for image slice interpolation. The Sum of Squared Difference is used as distance measure, and the above formulation of equation (2) can be rewritten in the form of equation (3):

\[ D[R₁(x - u), R₂(x + u)] = \frac{1}{2} \int_Ω (R₁(x) - R₂(x + u(x)))² \ dx. \]

(3)

Here the curvature registration [8] approach is used for smoothing the term ‘RS’, is as follows:

\[ RS^{curv}[u] = \frac{1}{2} \sum_{i=1}^{d} \int_Ω (\Delta u)^2 \ dx \]

(4)
From equation (4) - where ‘Δ’ is the curvature operator, the summation is computed over two dimensions of image slices, the integral is computed inside the domain of images and it also shows an approximation to the curvature of the ‘lth’ component of displacement field ‘u’.

Fig 2: Pictorial representation of Interpolation of Slice in 3D model

3. Experimental Results

Fig 3: Interpolation by colored slices

Fig 4: Resultant Images Shows the Reconstruction of 3D model using Deterministic method of Linear Interpolation by Curvature based Image Registration
4. Summary and Conclusion

The proposed Deterministic method of linear interpolation and curvature based image registration method uses the level set framework by a set of slices. Here proposed method uses an approach of displacement field calculation from both reference image and target image and interpolate the intensities of the missing slice by curvature based image registration. The mathematical implementation of the proposed method is accomplished and the 3D model is represented by a set of 2D image slices as a level set [6] of a topological function, later it is used to display the surface by a proposed method. This permits in improving the surface and shape of the 3D model. The current implementation was performed in openGL. Part of future work will be an extension of reconstruction of 3D model [3][4] from rendering of interpolated slices.

5. References


