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A New Medical Image Registration ⋆

Meisen Pan*, Fen Zhang, Jianjun Jiang

College of Computer Science and Technology, Hunan University of Arts and Science Changde 415000, China

Abstract

This proposed method calculates the centroids of two registering images by applying the moments for acquiring the original displacement parameters, and then uses modified K-means clustering to classify the image coordinates. Before clustering, the medical image coordinates is centralized, the two-row coordinate matrix is created to construct the 2-D sample set to be partitioned into two classes, the slope of a straight line fitted to the two classes is computed, and the rotation angle is computed by solving the arc tangent of the slope. The edges are detected by the edge convolution kernel and the binary images covering the characteristic points are extracted. Experimental results from aligning experiments reveal that, this approach has lower computation costs and a higher registration precision.

Keywords: Centroids; Image Registration; K-means Clustering; Iterative Closest Points

1 Introduction

Medical image registration signifies that the space geometry transform is applied to register several images created by various imaging devices, and makes the pixels (voxels) expressing the identical construction be the same spatial position [1,2]. After years of development and evolution, the methods for registering medical images have achieved rapid advance, and global experts and scholars have proposed many practical and effective technologies. Among these methods, characteristic-based image approaches have been extensively applied for aligning medical images [3]. For the characteristic-based alignment method, in essence, it extracts the conjunct, distinct and significant characteristics between the aligning the objects to explore the transform values. It is effective and easy to implement, while its alignment precision seriously counts on whether it can exactly extract the critical characteristic points [4–7]. In consideration of the complication of various images, it is really an intractable issue to solve the fully-automated and accurate abstraction and refinement of the useful characteristic points from medical images. So its poor adaptability and robustness need to be further boosted.

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*Corresponding author.
Email address: pmsjjj@126.com (Meisen Pan).

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In 1980's, the researchers made deep and systematic study about the registration of set of points. In particular, Arun et al. [8] introduced an approach to alignment between point sets using unit quaternion to represent rotation in 1987. A lot of aligning experiments have shown that the registration technology is an appreciated way to confront the thorny issues of alignment. In 1992, Besl et al. [9] pioneered the Iterative Closest Point (ICP) algorithm, to handle the problem of registration of point sets. ICP, as a characteristic-based registration method, is a very famous method and widely put into use in the registration of set of points. It can align the set of points without the requirement for segmentation or other preprocessing of the images. Therefore, it is more propitious for registering set of points [2]. So it is widely used in various alignment fields. However, it exists some problems that need to be resolved in the implement process. First, it must repetitive and iteratively explore the closest points, and as a result the computation costs are extremely expensive. Second, whether ICP can exactly derive the optimal registration parameters seriously dependent on the selection of the original rotation and displacement parameters. If the original values are not fitted to respond to ICP, then the registering operation has to take more time to explore the optima and even results in failure. In addition, it is troublesome to select the pivotal characteristic points delineating the object outline automatically when aligning images. Furthermore, it can effortlessly fall in the trap of the local optima.

In order to tackle the problems mentioned above, on the foundation of an in-depth study about the K-means Clustering (KMC) and ICP, we present medical image registration using Modified K-means Clustering (RMKMC).

2 Medical Image Registration Using Modified K-Means Clustering

2.1 ICP

Assume that sets $\boldsymbol{S}, \boldsymbol{F} \in R^K$, $\boldsymbol{S} = \{\boldsymbol{s}_i, i = 1, 2, \cdots, N\}$ with $\boldsymbol{s}_i = [s_{il} \ \cdots \ s_{iK}]^T$ and $\boldsymbol{F} = \{\boldsymbol{f}_j, j = 1, 2, \cdots, M\}$ with $\boldsymbol{f}_j = [f_{jl} \ \cdots \ f_{jK}]^T$ present the reference and floating sets respectively, and $\boldsymbol{Z} = \{\boldsymbol{z}_i, i = 1, 2, \cdots, M\}$ with $\boldsymbol{z}_i = [z_{il} \ \cdots \ z_{iK}]^T$ and $\boldsymbol{z}_i \in \boldsymbol{S}$ expresses the closest point set. In addition, $\boldsymbol{R}_0$ and $\boldsymbol{T}_0$ denote $K \times K$ rotation and $K \times 1$ matrices respectively. ICP introduced by Besl and Mckay is aimed at exploring a rigid transformation ($\boldsymbol{R}_0$, $\boldsymbol{T}_0$) to make the mean square sum representing the Euclidean distances between the set $\boldsymbol{F}$ mapped by ($\boldsymbol{R}_0$, $\boldsymbol{T}_0$) and its closest point set $\boldsymbol{Z}$ in $\boldsymbol{S}$ be minimized, i.e., the objective function

$$J(\boldsymbol{R}_0, \boldsymbol{T}_0) = Min\left\{\frac{1}{M}\sum_{i=1}^{M}\|\boldsymbol{z}_i - (\boldsymbol{R}_0 \cdot \boldsymbol{f}_i + \boldsymbol{T}_0)\|\right\} \tag{1}$$

here $\boldsymbol{R}_0$ is computed by the unit quaternion [9], and then $\boldsymbol{T}_0$ is obtained by

$$\boldsymbol{T}_0 = \overline{\boldsymbol{z}} - \boldsymbol{R}_0 \cdot \overline{\boldsymbol{f}} \qquad \left(\overline{\boldsymbol{z}} = \frac{1}{M}\sum_{i=1}^{M}\boldsymbol{z}_i, \overline{\boldsymbol{f}} = \frac{1}{M}\sum_{i=1}^{M}\boldsymbol{f}_i\right) \tag{2}$$

In ICP, the original rotation matrix $\boldsymbol{R}_0^0$ and the translation matrix $\boldsymbol{T}_0^0$ are set by $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$