

## Multimodal Medical Image Deformable Registration

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**Abstract.** The clinical diagnosis and treatment of patients suffering from brain abnormalities usually require exhaustive exploration of biomedical images. However, images of a single modality do not provide a set of information. The inadequacy of clinical information makes a biomedical image of single modality insufficient for use in clinical interpretation and diagnosis of disease. In general, information acquired from images resulting from different modalities is complementary in nature. Fusion of multimodal images can be achieved after registration of two images. Registration process takes care of two images getting into on single alignment considering any one of the image as a reference. There different types of registration methods are available. Rigid registration and non-rigid (deformable registration) are the two types of registrations. Rigid registration methods consider the only rigid structure, like boundaries and edges present in the images. Deformable registration method looks into the geometrical deformation present in the images. Considering the medical images, geometric deformation referred to the soft tissues behavior during the interventional procedure or due to the over a period of time changes takes place in the tissue. Deformable registration has become more important in recent days. Proposed article deal with the study on appropriate deformable registration for multimodal medical images.

**Keywords:** Bspline, deformable registration, demons, Finite Element Model(FEM), rigid registration.

### 1. Introduction

Medical images such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) gives the complementary information. CT gives information about the rigid structures and MRI gives better characterization of the soft tissue. It is better to combine both the information into one. Combining the complementary information into one can be achieved by fusing multimodal medical images such as, CT and MRI.

Challenges occur during fusion of multimodal images is geometry of the two images. That is, considering CT and MRI, both are of different physics and angle of image acquisition are different. In this case our challenge is to get both complementary images to get moved to the same coordinates. This can be achieved by image registration.

Image registration is a process, which involves two images and tends to find a geometrical transformation that maps one image to the other one, such that each anatomical point in one image gets moved to the same coordinates as the corresponding anatomical point in the other image.

Image registration enables to integrate different images into one representation such that the complementary information can be accessed more easily and accurately [1].

### 2. Image Registration

Image registration is the process of aligning two images into same geometry or photometry. Image registration can be done on images of same patient (mono-modality) or different patient (multi-modality). Proposed technique involves mono-modality images. Figure 1 show the basic framework of image registration.

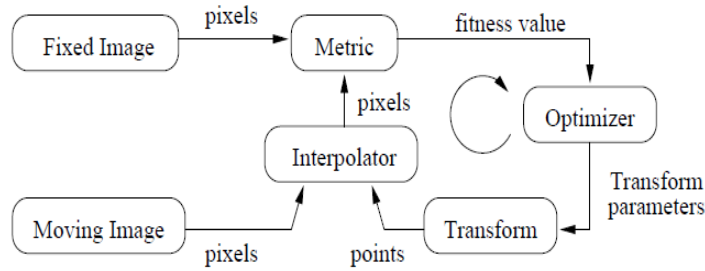


Figure 1: The basic components of the registration framework.

Basic components of registration frame work are two input images, metric, optimizer, transform and interpolator. The number of parameters selected for the metric are the standard deviation of the Gaussian kernel for the fixed image density estimate, the standard deviation of the kernel for the moving image density and the number of samples uses to compute the densities and entropy values.

Two input images are given to registration frame work, considering one as fixed image and other as moving image. Fixed image is a target image and moving image gets moved to the same coordinates of the target image. Outcome of the registration is moving image transformed to the geometry of the target image. In the proposed work CT image is considered as a fixed image and MRI is considered as a target image. Interpolator computes pixel values in the moving image only. Metric measures how well the moving image is matched with target image after transformation. Transformation maps the points in moving image with points in target image. Different types of transformations are rigid (rotate and translate), affine (rigid+ scale & shear) and deformable (affine + curvature) etc. Optimizer analyses the transformation parameters in order to maximize the quality of image alignment. Optimizer steps through a user defined iterations.

### 3. Deformable Registration

Deformable registrations have more importance in the recent days because the majority of the rigid registration deals with the condition of rigid structures, which would not create accurate results [6]. Considering the point that soft tissues can change in shape during an intervention, sophisticated registration is essential for geometrical deformations. Following gives the information about different types of deformable registrations implemented.

#### 3.1. Bspline Deformable Transform

Bspline is designed to be used for deformable registration problems [2]. This transformation generates deformable fields where deformation vectors are assigned to every point in the space. Bspline grid is used to locate deformation point values in interpolation for moving images. It is defined only when both input and output have same dimensions. It requires long computational time because it has very high dimensional parametric space. Figure 2 shows the inputs and output of the Bspline deformable registration.

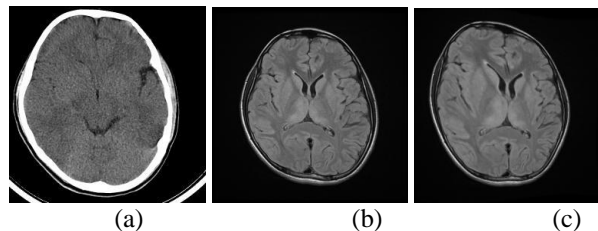


Figure 2: (a) Target image-CT (b) Moving image-(MRI) (C) Resultant image-(Registered MRI).

#### 3.2. Demons Deformable Registration

Demons is more of a framework than an algorithm. It is fast and accurate but it is based on intuitive ideas based on image registration. It is difficult to predict that when it fails and why [3]. Demons is implemented as finite difference solver framework in the proposed paper, it is depend on the assumption that the values of the pixels representing same homologous point have the same intensity on the both the image (target and

moving) to be registered. For robustness histogram is matched to remove the background of the images. Figure 3 shows the inputs and output of demons deformable registration.

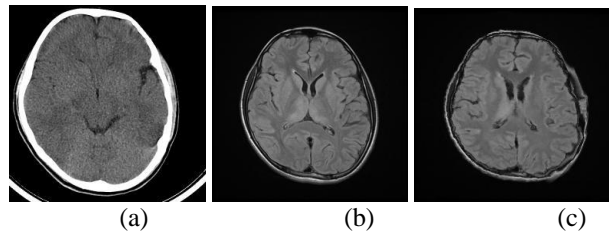


Figure 3: (a) Target image- CT (b) Moving image – MRI (c) Resultant image – registered MRI

### 3.3. FEM Based Deformable Registration

Finite Element Modeling initially discretizes the deformable fields using anatomy specified grids for the desired geometry. Geometry of the object is segmented into small elements. FEM consider the force, displacement and regularization in the image. Product of displacement and linearization of physical model and node displacement gives the image based forces. The continuous form of the solution is determined by interpolation functions for every point inside each element [6]. These functions are based on the displacement of the nodes specifying the element. Elements are connected at nodes at which displacement is solved. Figure 4 shows the results of FEM based deformable registration.

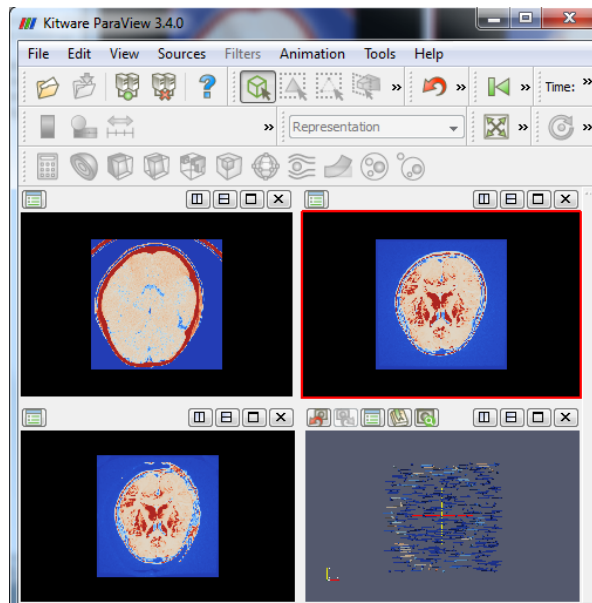


Figure 4: Results of deformable registration using FEM algorithm.

## 4. Conclusion

Multimodal medical images should be fused to combine the complementary information. Prior to fuse multimodal images, those images should be aligned into a particular geometry. Deformable registration transformations types considered in proposed work are Bspline, Demons and Finite Element Modeling. Looking at the results, it is observed that Bspline transformation works better for multimodal image registration for further fusion. Demons and FEM can be used for mono-modality image registration.

## 5. References

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