CT and MRI Brain Images Matching Using Ridgeness Correlation

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ABSTRACT

Image registration is considered as one of the most fundamental and crucial pre processing step in digital image processing. Since it is a vital problem in medical imaging, though it has several applications in clinical diagnosis such as diagnosis of cardiac, retinal, pelvic, renal, abdomen, liver, tissue etc disorders. Ridges, edges and troughs are useful geometric features for image analysis. Geometrical image features like ridges in digital images may be extracted by convolving the images with Gaussian kernels. In this paper we will perform the task of using ridgeness correlation for CT and MRI brain images matching using scale space method and also demonstrate 3D CT – MRI image registration with a software package using rigid translations and rotations.

Key words: Ridges, Ridgeness, Troughs, Image registrations/matching, Multi resolution correlation

INTRODUCTION

Image registration is a process of overlaying two images geometrically. Image registration can be classified into (1) multi view (2) multi temporal (3) multi modal. There are abundance of image registration techniques. The various areas where image registration is beneficial are remote sensing, image mosaicing, image fusion, medicine. The details of techniques can be found in[1]. The tomography imaging modalities such as CT, MRI, PET, SPECT are briefly explained in[4,5,6]. While integrating the two modalities the first step is image registration and second step is image fusion[16]. In this paper ,we will discuss the first step only.

Ridges

Ridges are rough top of anything. It seems to narrow elevation. Ridges are briefly explained in[2,4,7,8,9]. Whereas troughs are reciprocal of ridge. The geometric definition of ridges & valleys in 2D &

N dimension are explained in[2]. Figure 1 shows clearly prominent ridge[4].

In the application of CT and MRI registration, the image ridgeness seems to be useful feature, as the skull ridge is most prominent in a CT image, and inverse ridge like – wise prominent in an MRI image.

Scale space representation

Scale space is representation of multi scale signals. It is developed by image processing & signal processing communities. It is terminology to handle various image structures at different scales. Scale space stated well in[3,10]. Scale space as stated by dr. petra van den elsen[11,12].

Measure of ridgeness

Many techniques have been developed to detect ridges over the century by Maxwell 1889, koenderink & van doorn 1994. There are lot of geometrical invariants to detect ridges in the image

structures (eberly at el. 1994). In this paper, selected Lvv operator to detect ridge structures that is well explained in[11,13].

Why skull ridge?

Skull has deformable nature so it is excellent structure of matching CT & MRI modalities of brian. Figure 2 shows CT slice, figure 3 depicts the landscape version of CT slice. This is basically an intensity landscape. In original image skull ridge is jagged (spikes). So resort to the use of scale space methods for detecting ridge. Figure 4 shows the CT landscape but now smoothed by convolution with a Gaussian. Now applying 3DLvv to CT set, the resultant image shows skull ridge. Now this ridged imaged is superimposed onto the original CT slice efficiently and precisely. Similar examples can be shown in MR data sets (figure 5, 6, 7) respectively.
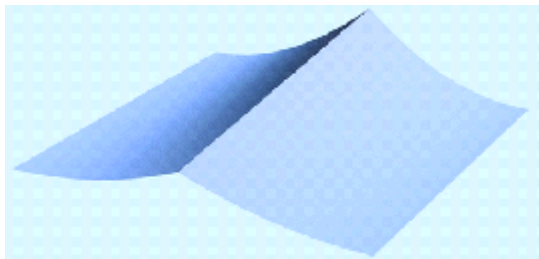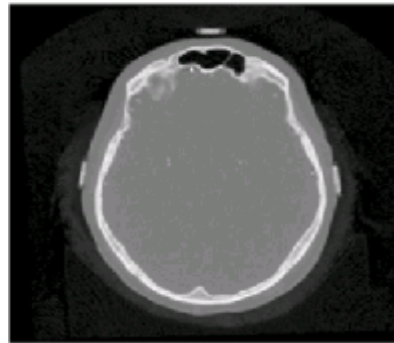

Fig. 1: A Clearly Prominent Ridge
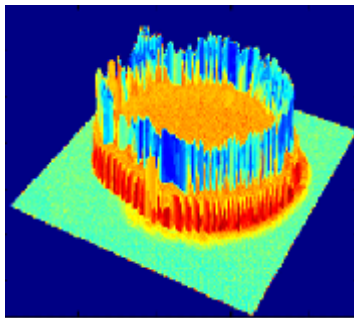

Fig. 2: CT Slice

Fig. 3: Intensity Landscape Version of Ct Slice in Previous Figure
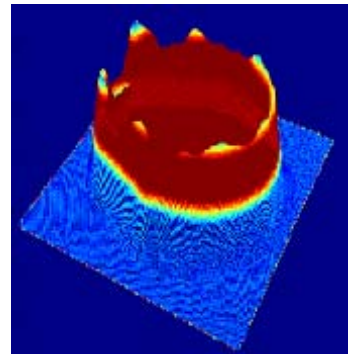

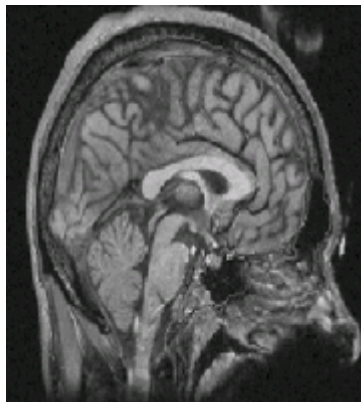**Fig. 4: The Landscape Version of Previous Figure Again Now Smoothed By Gaussian Convolution**
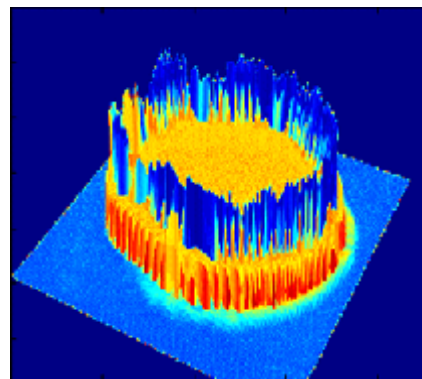

Fig. 5: Mri Data Set

Fig. 6: Landscape Version of MR Data Set

In MR image the skull area is dark so troughs or inverse ridge are detected. As we overlaid the ridgeness image onto the CT and MR datasets ,the 3DCT and MR ridgeness volumes(L1 and L2)is created as shown in figure(8&9) .

Matching of 3D CT and MR Volumes

The registration of 3DCT and MR ridgeness volume (L1 and L2) using correlation

$$c(t) = \sum_{(x,y,z) \in L_1} L_1(x,y,z) L_2(t(x,y,z)).$$

In this method, user subjectivity is avoided, there is no user interaction & fully automatic. Only disadvantage related to this technique is high computational effort required.

RESULT

Resultant match of 3D CT ridgeness and 3D MR ridgeness is shown figure 10. Figure 11 shows zoomed or detailed view of selected part.
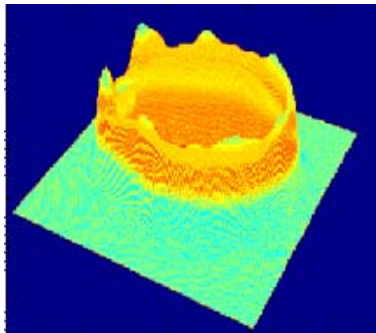
3D Image registration of CT and MRI brain images[17]

Till now, the matching of CT and MRI brain images was fully automatic. There was no time consuming user interaction required and total users subjectivity was avoided. High computational effort was the disadvantage of above mentioned matching of CT and MRI images. Now we will demonstrate the 3D CT and MRI registration where the user interaction is needed. Thus it is called interactive registration . With this interactive registration, a source image can be registered against a target image of different or same modality. The source images shown in figure 12 and figure 13 shows target images. A source images is to be register on target images ,figure 14 is a registered image.

This new registered image is formed and can be used for fusion and 3D modeling application. The transforms (Rotation, Translation & Scaling) of source, target and the registered image is shown in table -1 (a, b, c) for source image, table -2 (d, e, f) for target image & table -3 (g, h, I) for registered image.
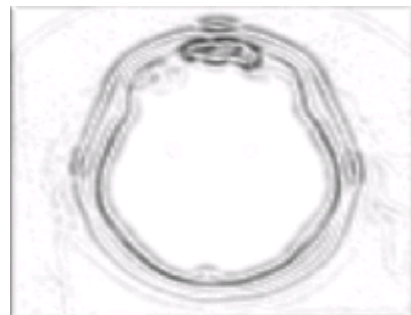

Fig. 7: Landscape Version of Previous Figure Now Blurred With Gaussian Kernel

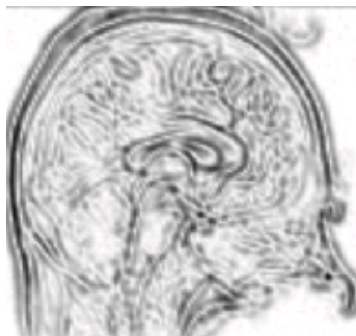**Fig. 8: 3d CT Ridgeness Volume (L1)**

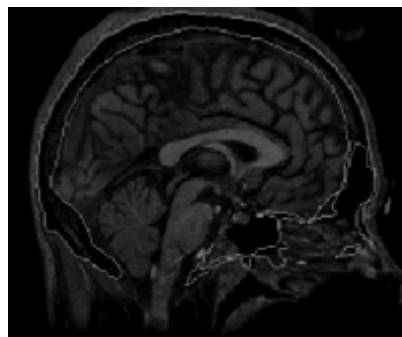**Fig. 9: 3D MR Ridgeness Volume (L2)**

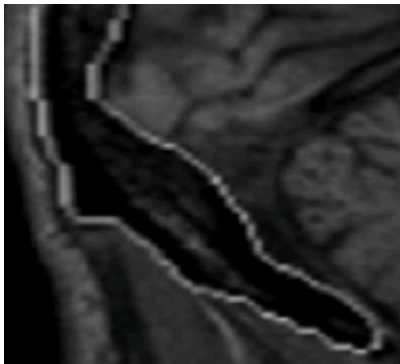**Fig. 10: After Matching Using Ridgeness Correlation**

Fig. 11: Zoomed or Detailed View of Previous Image (Using Ridgeness Correlation)

Fig. 12: MRI Source Image(courtesy-3D DOCTOR SOFTWARE)

Fig. 13: CT Target Image(courtesy-3D DOCTOR SOFTWARE)

Fig. 14: Registered Image (courtesy-3D DOCTOR SOFTWARE)

Table 1: (a, b, c) (courtesy-3D DOCTOR SOFTWARE)

Rotation	
X	0
Y	0
Z	0
(a)	

Translation	
X	0
Y	0
Z	0
(b)	

Scale	
X	1
Y	1
Z	1
(c)	

Table 2: (d, e, f) (courtesy-3D DOCTOR SOFTWARE)

Rotation	
X	0
Y	0
Z	0
(d)	

Translation	
X	0
Y	0
Z	0
(e)	

Scale	
X	1
Y	1
Z	1
(f)	

Table 3: (g, h, I) (courtesy-3D DOCTOR SOFTWARE)

Rotation	
X	90
Y	0
Z	90
(g)	
Translation	
X	-10
Y	-2
Z	-15
(h)	
Scale	
X	1.1
Y	0.1
Z	1.2
(i)	

Applications of CT-MRI registration

Matching of MR & CT images of head can be useful in planning neuro surgical & ENT surgical procedures. The matching of CT & MRI modalities are used in radiotheraphy planning. It is used in prophylactic cranial radiotherapy.

CONCLUSION AND DISCUSSION

The terms matching and registration are both used to donate the process of determining the transformation that relates the content of two images in a meaning full way. In the former part of this paper, we use 3D CT & MR ridgeness volumes in a multi resolution correlation method. This scheme required no interactive actions and devoid of human subjectivity. In the later part of this paper interactive registration task is done where the user interaction is needed. In these interactive registration patient related geometrical features is not needed.

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