

Robust Image Warping Using Joint Saliency Map

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Abstract—Mutual information (MI) is a popular similarity measure for image registration, whereby good registration can be achieved by maximizing the compactness of the clusters in the joint histogram. However, MI is sensitive to the “outlier” objects that appear in one image but not the other, and also suffers from local and biased maxima. We propose a novel joint saliency map (JSM) to highlight the corresponding salient structures in the two images, and emphatically group those salient structures into the smoothed compact clusters in the weighted joint histogram. This strategy could solve both the outlier and the local maxima problems. Experimental results show that the JSM-MI based algorithm is not only accurate but also robust for registration of challenging image pairs with outliers.

Index Terms—Image registration, joint saliency map, mutual information, outliers, weighted joint histogram.

I. INTRODUCTION

IMAGE registration is a fundamental task in many

(JSM) JSM
 0 1 F. 1(,) JSM
 T JSM (RSV). T RSV
 (PAA)
 (WJH), JSM-
 T JSM-MI
 2-D E, MI-
 MI- JSM-MI
 W JSM WJH MI
 N F

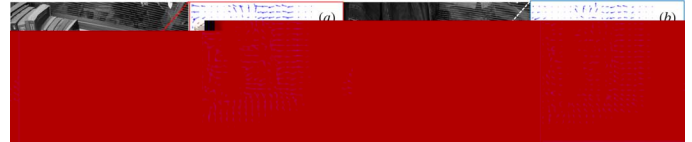


Fig. 2. (a) (b) RSV $\mu = 28$ ($\sigma = 47$) $\mu = 8.3$ ($\sigma = 47$)

II. METHODS

A. Regional Saliency Vector

W M
 12, 13, 14, Gr
 MI- 9, 11, H
 L 12
 C 15
 I 16, 17
 :

$$S_l(v) = \sum_{u \in N_v} (I_l(v) - I_l(u))^2 \quad (2)$$

$$v = (x, y) \quad l, S_l(v) \quad I_l(v) \quad G \quad I_l(v) \quad S(x, y) \quad (3)$$

I PAA
 regional saliency

$$M = \begin{bmatrix} \mu_{20} & \mu_{11} \\ \mu_{11} & \mu_{02} \end{bmatrix} \quad (3)$$

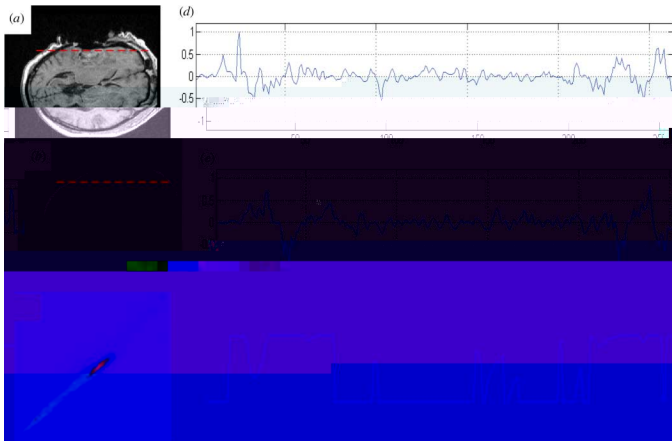


Fig. 3. (a) T1-weighted MRI brain scan. (b) Joint Saliency Map (JSM) of the brain scan. (c) JSM-WJH (JSM-Weighted Joint Histogram) of the brain scan. (d) Registration error over time for the brain scan. The shaded green area represents the error range.

C. JSM-Weighted Joint Histogram

To register two images, I_1 and I_2 , we first extract their Joint Saliency Maps (JSM) and JSM-Weighted Joint Histograms (JSM-WJH). The JSM is a 2-D histogram that captures the joint saliency of the two images. The JSM-WJH is a 2-D histogram that captures the joint saliency of the two images, weighted by their respective saliency maps. The registration process is then performed by finding the maximum correlation between the JSM-WJH of the two images. This process is computationally intensive, as it requires a full search over all possible translations. To reduce the computational complexity, we propose a fast registration algorithm based on the JSM-WJH. This algorithm uses a coarse-to-fine registration strategy, where the registration is first performed at a low resolution and then refined at higher resolutions. This approach significantly reduces the computational complexity while maintaining high registration accuracy.

D. Computational Complexity

The computational complexity of the proposed registration algorithm is significantly lower than that of traditional registration methods. The complexity is primarily determined by the size of the images and the resolution of the registration. For a typical brain scan with a resolution of 256×256 pixels, the proposed algorithm has a complexity of approximately 7.9×10^6 operations, which is much lower than the complexity of traditional methods.

TABLE II
COMPUTATION ITERATIONS AND RUNTIME IN SECONDS FOR FIG. 4.
(MATLAB 6.5, SINGLE CORE INTEL CELERON 2.8 GHZ, RAM 2 GB)

	JMI	NMI	RMI	HMI	GMI	PMI
Iter.	64	41	45	46	50	29
Time	157.4	296.7	297.1	1060.1	329.1	3049.3

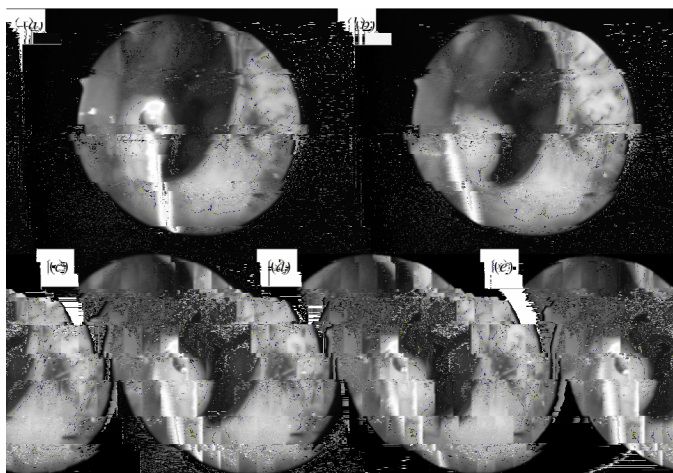


FIG. 5. (a) Original MRI slice. (b) Denoised MRI slice. (c) Segmented MRI slice. (d) Segmented MRI slice. (e) Segmented MRI slice. (f) Segmented MRI slice. (g) Segmented MRI slice. (h) Segmented MRI slice. (i) Segmented MRI slice. (j) Segmented MRI slice. (k) Segmented MRI slice. (l) Segmented MRI slice. (m) Segmented MRI slice. (n) Segmented MRI slice. (o) Segmented MRI slice. (p) Segmented MRI slice. (q) Segmented MRI slice. (r) Segmented MRI slice. (s) Segmented MRI slice. (t) Segmented MRI slice. (u) Segmented MRI slice. (v) Segmented MRI slice. (w) Segmented MRI slice. (x) Segmented MRI slice. (y) Segmented MRI slice. (z) Segmented MRI slice.

JSM [13] is used for denoising. The denoised MRI slice is then segmented by NMI [14]. The segmentation results are compared with the ground truth. The segmentation results are shown in Fig. 5. The segmentation results are compared with the ground truth. The segmentation results are shown in Fig. 5. The segmentation results are compared with the ground truth. The segmentation results are shown in Fig. 5.

IV. CONCLUSION

We propose a novel method for MRI slice denoising and segmentation. The method consists of two main steps: denoising and segmentation. The denoising step is performed using JSM [13]. The segmentation step is performed using NMI [14]. The segmentation results are compared with the ground truth. The segmentation results are shown in Fig. 5. The segmentation results are compared with the ground truth. The segmentation results are shown in Fig. 5.

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