R I W O U J S M

B Q , *Member, IEEE*, G , S , L

096 55.09.005.4166138.35867574.0267 99OBT929626005.4241142.4.843 T 664675

***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

T

I , $p(i)$ $p(r) = \sum_f p(r, f)$ $p(f) = \sum_r p(r, f)$, $p(r, f)$ $h(r, f)$.

MI-

3 . T

. W

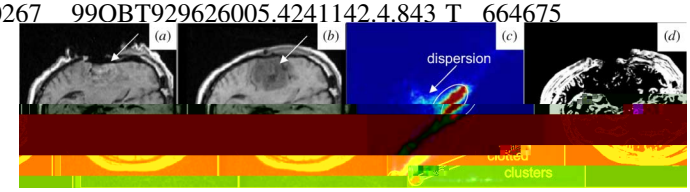
M A , 08, 2009; S 27, 2009. F O 06, 2009; O 28, 2009. T NSFC (60872102), NBRPC (973 P 2010CB834303), S F S M S & T C (04JC14060), S M H B (2008115), S A I P (06-545). T P . H. V .

B. Q , . G , . S, D B E , S L S & B , S J T U , S 200240, C (- : @ ; 0126@ ; @).

L D M , S J T U , S 200240, C (- : @).

C ://

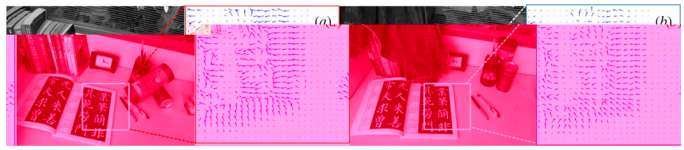
D O I 10.1109/LSP.2009.2033728



F . 1. ( ) ( ) I - - MR . ( ) J ( ). ( ) J ( ) ( ).

. M , MI , . - - - F . 1( ) ( ) . T 4 , - 5 , - MI 6 - MI 7 . H . F , MI 8 - . S , MI 9 12 - . N , MI- . T : 1) . T F . 1( ) ; 2) F . 1( ) , MI 8 (F . 5( ) MI 1 , 20); 3) MI . T , ( ) 5 , 8 . W . I , . T , . F ,

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



II. METHODS

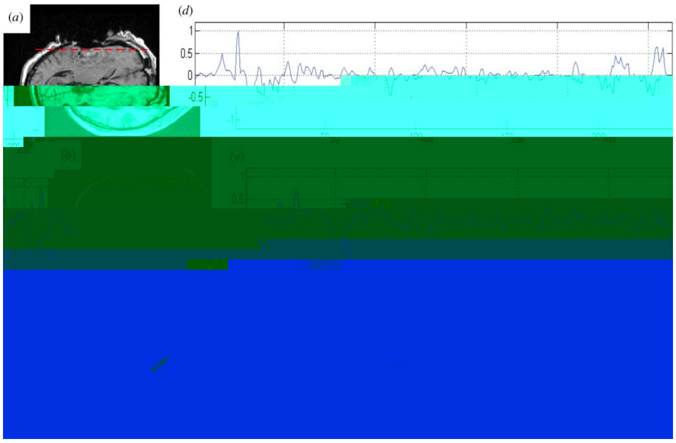
A. Regional Saliency Vector

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

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

N_v 1-
$v = (x, y)$ l, $S_l(v)$ -
$I_l(v)$ G 18
l, $I_l(u)$ $I_l(v)$' -
. T $S(x, y)$
.
I , PAA
regional saliency
:

$$\boldsymbol{M} = \begin{bmatrix} \mu_{20} & \mu_{11} \\ \mu_{11} & \mu_{02} \end{bmatrix} \tag{3}$$



F . 3. ( ) ( ) T ... JSM ... ( ) C ... JSM-WJH ... ( ) ( ). ( ) ( ) G ... ( ) ( ), ... ( ) JSM ... ( ) ( ).

C. JSM-Weighted Joint Histogram

T ... $f(v_f)$ ... $w(v)$ ... JSM (... (v_r, v_f) ... v). F 2-D ... , ... $w(v)$ ... $h(r, f)$. I ... (PV) - ... , ... $f(v_f)$ ... , ... v_r ... I_R, ... $w(v)$. S ... , JSM ... P - ... .

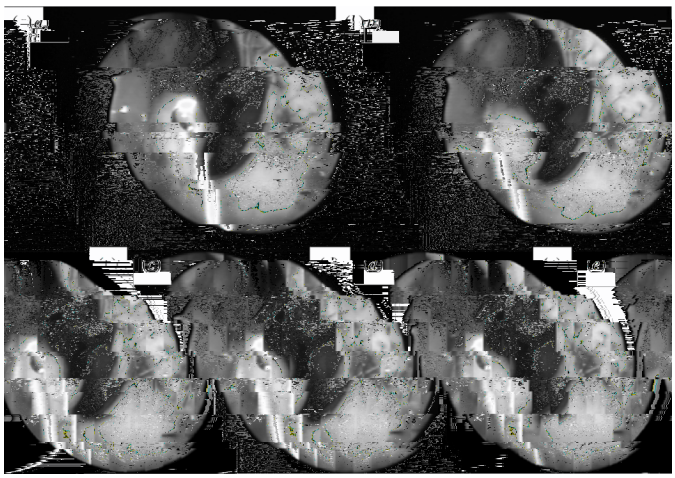
I ... JSM-WJH, ... F ... , ... , ... - ... . A ... , ... F . 3( ) ... . C ... - ... , MI ... .

D. Computational Complexity

T JSM ... .99 ... .7( )-428 ... ( )-309.3(... 1021TD ( )-182.9 ...)-174..1- ... 69-16787.6

TABLE II
COMPUTATION ITERATIONS AND RUNTIME IN SECONDS FOR FIG. 4. (MATLAB 6.5, SINGLE CORE INTEL CELERON 2.8 GH , 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



F . 5. ( ) ( ) R fi (: 720 × 572) . T . ( ) NMI. ( ) PMI. ( ) JMI.

JSM - , NMI .

F . 5( ) ( ) fi - (720 × 572) . U , , F . 5( ) ( ) NMI- PMI- - . F . 5( ) JMI- - (T I. 2).

IV. CONCLUSION

W JSM - MI- . R - , JSM - 3-D . I - 23 , 24 , O *et al.* 25 3-D . A , - . I , . N , .

ACKNOWLEDGMENT

T S. K. W , M. I , R. B E. V , R. A , S. T , W. W .

REFERENCES

1 F. M , A. C , D. V , G. M , P. S , M , – *IEEE Trans. Med. Imag.*, . 16, . 2, . 187 198, 1997.
2 P. V W. M. W , III, A , – *Int. J. Comput. Vis.*, . 24, . 2, . 137 154, 1997.
3 J. O , M fi , – *Med. Image Anal.*, . 12, . 4, . 385 396, 2008.
4 M. A , P. R , G. A. H , A , – *IEEE Trans Image Process.*, . 14, . 4, . 475 486, 2005.
5 P. L F. P , A , – *Image Vis. Comput.*, . 19, . 1 2, . 33 44, 2001.
6 D. T , B. L , F. P , 3-D/2-D - , 2-D 3-D, – *IEEE Trans. Med. Imag.*, . 25, . 1, . 17 27, 2006.
7 M. S , U. A. H , S. K , M. A. V , J. P. W. P , R MRI , – *IEEE Trans. Med. Imag.*, . 28, . 9, . 1412 1421, 2009.
8 J. T , I , – *IEEE Trans. Med. Imag.*, . 22, . 7, . 854 864, 2003.
9 R. G , A. C. S. C , S. L , M , – *Med. Image Anal.*, . 12, . 4, . 452 468, 2008.
10 J. P. W. P , J. B. M , M. A. V , I , – *IEEE Trans. Med. Imag.*, . 19, . 8, . 809 814, 2000.
11 R. B , J. A. F , B. K , A , – *IEEE Trans. Med. Imag.*, . 28, . 8, . 1208 1216, 2009.
12 M. M M. B , P , – *Med. Image Anal.*, . 9, . 4, . 330 343, 2005.
13 T. K M. B , S , – *IJCV*, . 45, . 2, . 83 105, 2001.
14 D. G. L , D , – *Int. J. Comput. Vis.*, . 60, . 2, . 91 110, 2004.
15 H. L , F. Q , L. C , D. S , M , – *Pattern. Recognit.*, . 41, . 1, . 285 298, 2008.
16 L. I C. K , C , – *Nature Rev. Neurosci.*, . 2, . 3, . 194 203, 2001.
17 F. L M. G , R , – *IEEE ICME 2006*, 2006, . 1477 1480.
18 M. J S. S , A , – *Med. Image Anal.*, . 5, . 2, . 143 156, 2001.
19 D. C. A , C. P , P. J. B , J. C. G , S , – *IEEE Trans. Med. Imag.*, . 20, . 11, . 1131 1139, 2001.
20 C. S , D. L. G. H , D. J. H , A , 3D – *Pattern Recognit.*, . 32, . 1, . 71 86, 1999.
21 D. R , C. T , T. R , C. M , I , – *ECCV 2004*, 2004, . 596 607.
22 J. K , H , – *IEEE ICIP 2004*, 2004, . 1779 1782.
23 . G B. Q , M , – *IEEE NSS-MIC 2006*, 2006, . 3209 3212.
24 B. Q . G , R , – *Proc. SPIE*, 2007, . 6833, . 683320-1 683320-11.
25 . O C. D , DRAMMS: D , – *IPMI 2009*, 2009, . 5636, LNCS, . 50 62.