Image Registration:
Introduction

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Image Registration and Fusion Systems

What is a digital image?

It is an array of scalars or vectors.

Scalar: *Reflectance, temperature, range*
Vector: *RGB, multispectral, hyperspectral*

126	132	124	120	126	124	116	132	126	106	100	104	122	130	120	108
130	136	124	124	124	126	126	132	128	114	104	104	126	136	122	112
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128	126	124	122	124	110	78	48	34	50	100	98	90	118	122	116
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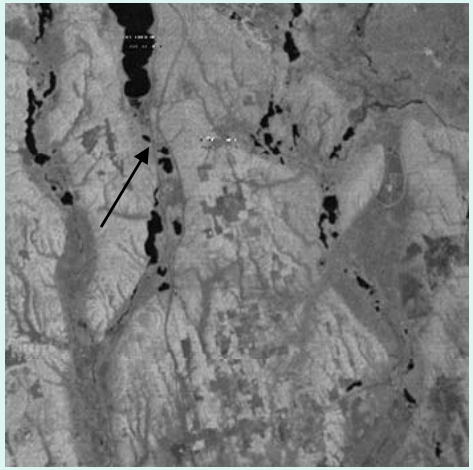
126	134	130	124	124	124	124	136	140	134	120	110	110	110	106	102
138	138	136	128	124	124	132	130	132	136	124	106	114	114	108	104

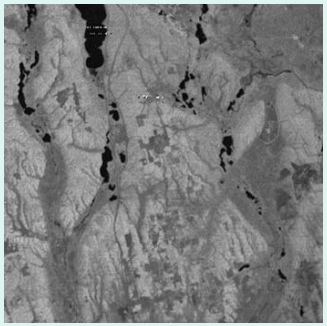
A digital image



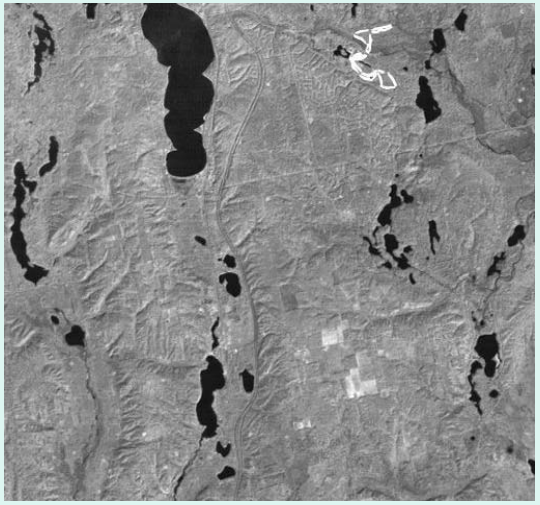
Landsat MSS image,
courtesy of NASA

What is image registration?

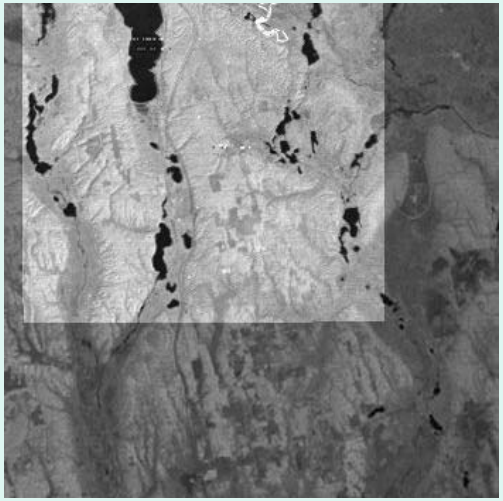
- It is the process of spatially aligning two or more images of a scene. The process in effect establishes point-by-point correspondence between the images.



Landsat MSS



Landsat TM

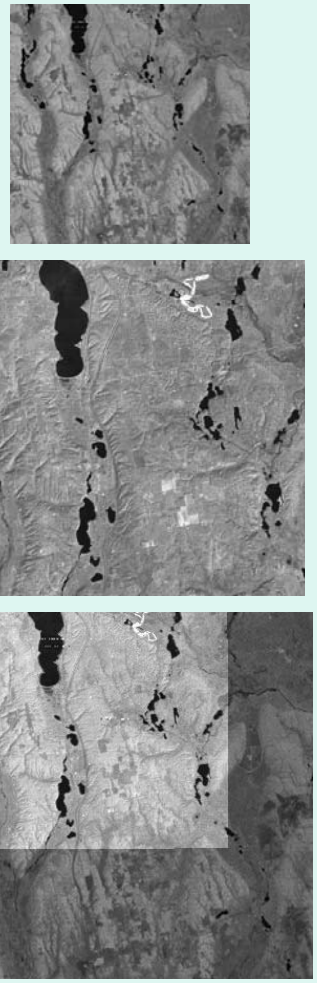


Registered MSS & TM

Data courtesy of NASA

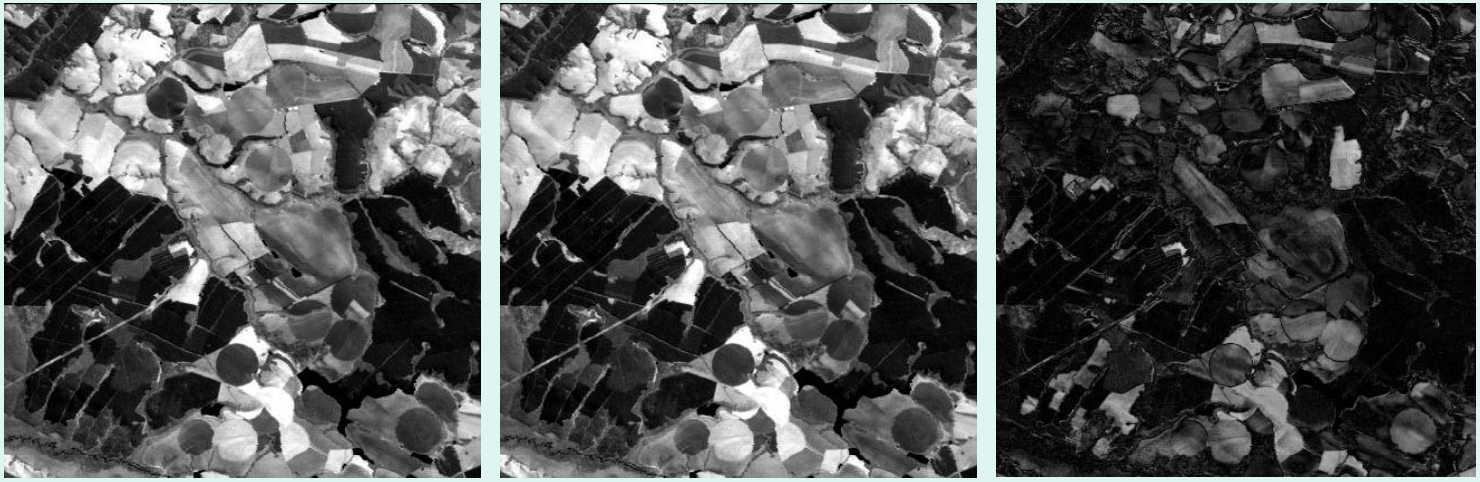
Terminologies

- **Reference or source image:** This is the image that is kept unchanged and is used as the reference.
- **Target or sensed image:** This is the image that is resampled to spatially align with the reference image.
- **Transformation function:** The function that is used to resample the target image to the geometry of the reference image.
- **Control points:** Unique landmarks in the images. Corresponding control points are used to determine the transformation parameters.



Applications of image registration

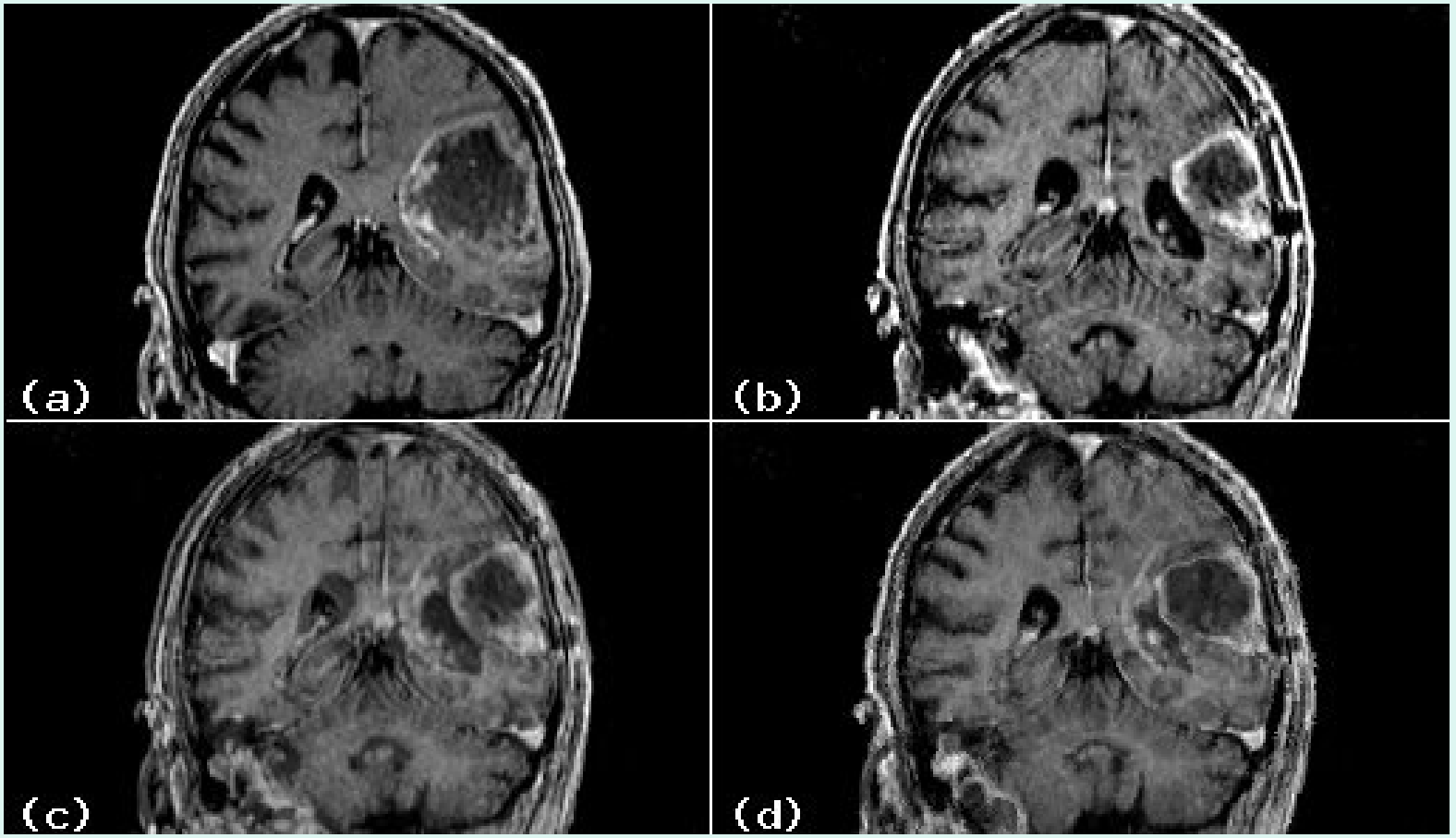
1. Change detection (intensity)



Landsat 1 Landsat 2 Change image

Data courtesy of NASA

2. Change detection (geometry)



(a), (b) Temporal MR brain images. (c), (d) Before and after registration.
Data courtesy of Kettering Medical Center.

3. Image flow computation

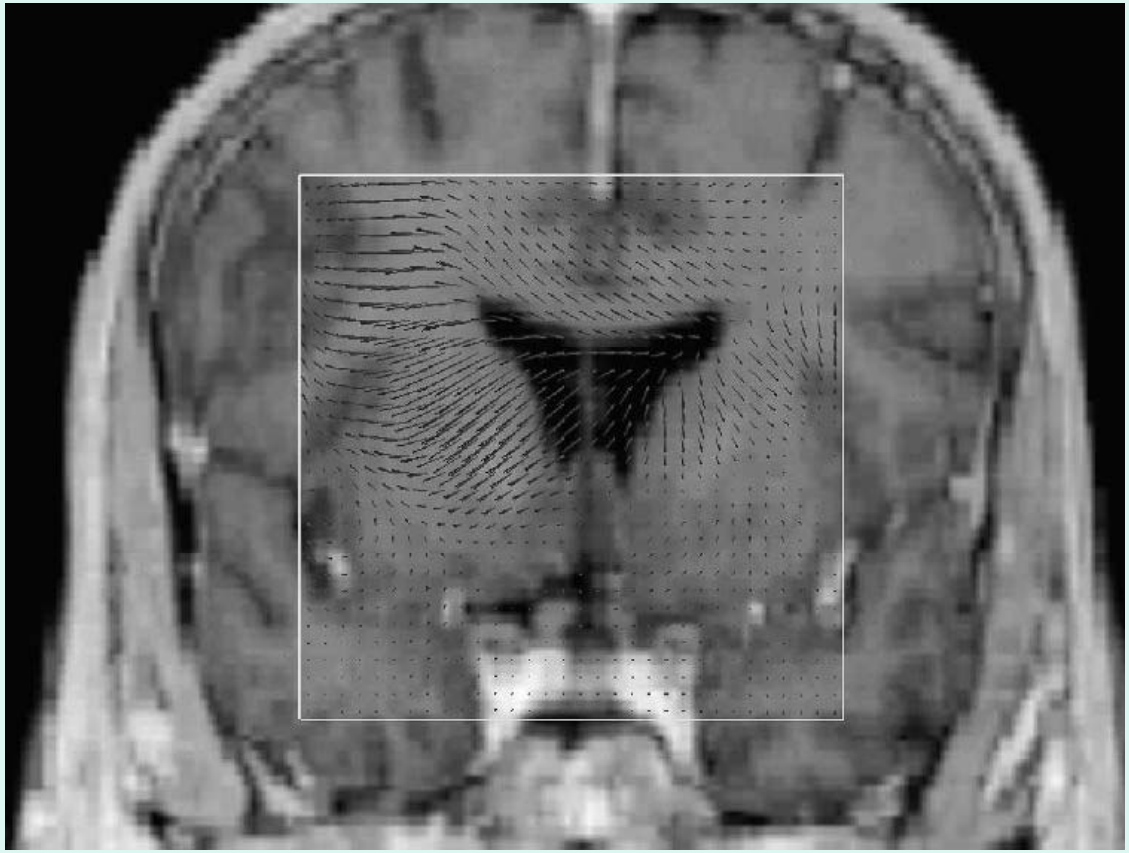
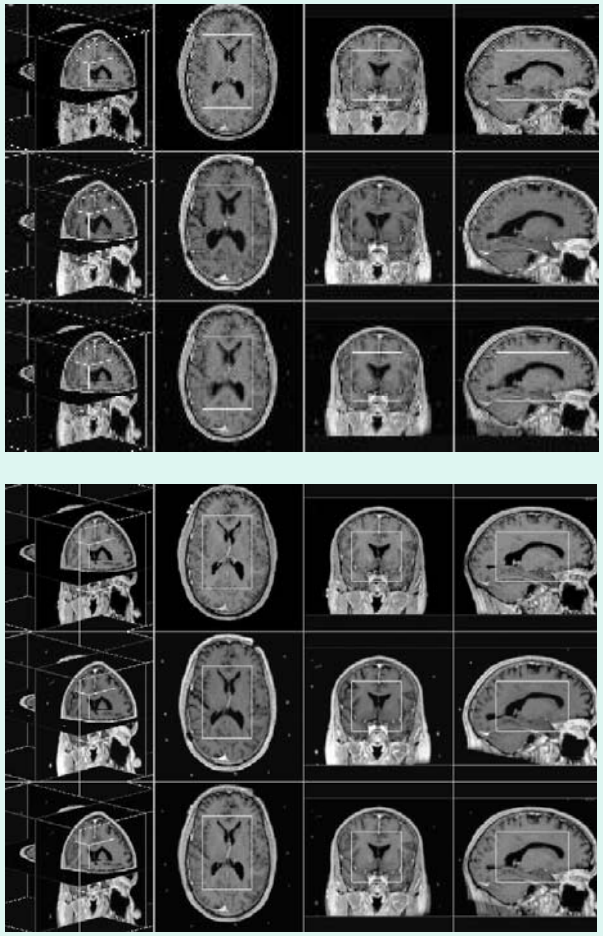


Image flow of one image slice



Temporal brain images

Data courtesy of Kettering Medical Center

4. Image fusion

Fused image

Landsat TM bands 1 & 7

Data courtesy of NASA

5. Image mosaicking

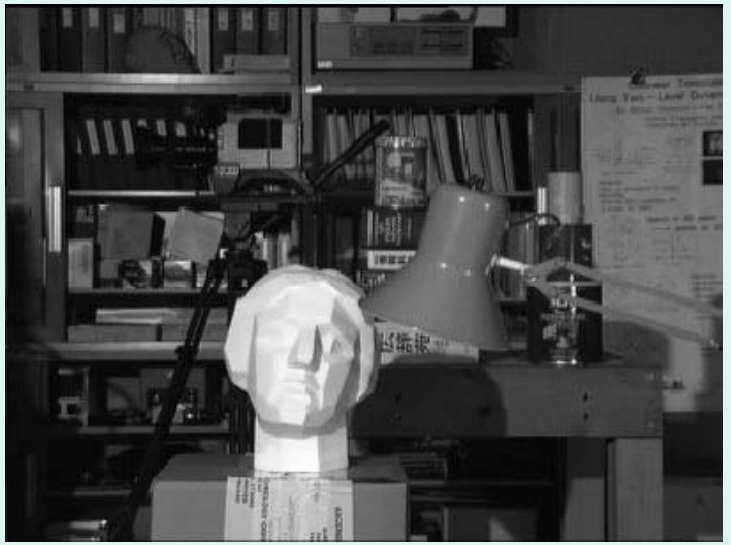
Mosaicked image

Two aerial images of Honolulu, HI.

6. Depth perception

Depth map

Data courtesy of Tsukuba University



A pair of stereo images

7. Other applications:

- Target localization
- Target recognition
- Target tracking
- Scene 3-D recovery

Steps in image registration

1. **Preprocessing:** Image smoothing, deblurring, image segmentation, edge detection
2. **Feature extraction and selection:** Extracting points, lines, regions, templates, etc. from images and selecting some
3. **Correspondence:** Determining the correspondence between selected features in images

4. **Determining the transformation function:** From the corresponding feature points determining the transformation parameters
5. **Resampling:** Resampling the sensed image to the geometry of the reference image using the transformation

Books and special issues on image registration

1. *Image Registration for Earth Science*, Jacqueline Le Moigne, Nathan Netanyahu, and Roger Eastman (Eds.), Cambridge Press, 2010.
2. *Landmark-Based Image Analysis: Using Geometric and Intensity Models*, K. Rohr, Kluwer Academic Publishers, Boston, MA, 2001.
3. *2-D and 3-D Image Registration*, A. Goshtasby, John Wiley & Sons, New York, NY, Feb. 2005.
4. *Non-Rigid Image Registration*, A. Goshtasby, L. Staib, C. Studholme, and D. Terzopoulos (Eds.), a special issue of *Computer Vision and Image Understanding*, Feb. 2003.
5. *Image Registration*, A. Goshtasby, J. LeMoigne (Eds.), a special issue of *Pattern Recognition*, Jan. 1999.
6. A survey of image registration techniques, Lisa Brown, *ACM Computing Surveys*, 8 (4):325–276 (1992).