Automatic Image to Image Registration for Multimodal Remote Sensing Images

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1. Introduction

Enormous increase in different characteristic remote sensing sensors and the prerequisite requiring fine registered multimodal images for applications like fusion, change detection and GIS overlay operations make automated multimodal image registration an important area of research. To achieve the elucidated task, a number of feature and intensity based image registration techniques are in vogue. Thanks to advancements in research, a basic framework for both the mentioned techniques has been established but still there is no conclusive research drawing guidelines for fine registration amongst remote sensing images acquired over various land cover classes. In the area of feature based registration, there is still no established technique to guarantee conjugate features amongst images with different characteristics. On the other side, in intensity based registration, similarity metrics like mutual information and cluster reward algorithm have proven their effectiveness to align multimodal images automatically but still a practical registration application to account for local deformations remains an open problem. This poster intends to review multimodal remote sensing image registration in context of latest and successful feature and intensity based registration approaches, related challenges and limitations to overcome in near future.

2. Image Registration

Mathematically, the problem of registering an input image (I_I) to a reference image (I_R) can be expressed as (Brown,1992):

$$I_R(x,y) = g\left(I_I\left(T(x,y)\right)\right)$$

$$(x',y') = T(x,y)$$

Where T is a transformation function which maps two spatial coordinates x and y to the new spatial coordinates x' and y' and g is a one dimensional radiometric interpolation function. The problem is depicted in Figure 1.

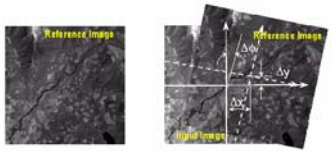

Figure 1: A pictorial representation of the image registration problem. The spatial transformation between the reference and the input image may compose of a rigid body or affine transformation containing scale, rotation and translations in x and y direction.

3. Approaches to Image Registration

Image registration techniques to register multimodal, multitemporal and different viewpoint remote sensing images can be classified into:

- Feature Based Techniques
- Intensity Based Techniques

3.1 Feature Based Techniques

Feature based techniques depend on accurate identification and matching of features or objects that describe important landmarks, sharp edges or shapes, which however may often be difficult to extract.

3.1.1 SIFT Operator

The Scale Invariant Feature Transform (SIFT) operator (Lowe, 2004) operator has been found useful to detect and match stable features amongst different images. SIFT operator has been accredited to detect and match scale and rotation invariant features. A big success in the field of computer vision and pattern recognition, for remote sensing imagery, SIFT operator can be successfully applied for *multimodal, multitemporal optical* and has also shown usefulness for geometric registration of *multimodal and multitemporal SAR imagery*. SIFT operator follows the depicted (Figure 2) methodology to identify and match stable features amongst images.

3.1.2 Limitations and Challenges

- Robustness of technique can suffer for feature less and really changed multitemporal scenes
- No established processing chain to identify and match features in multimodal cases like images from SAR and optical sensors.

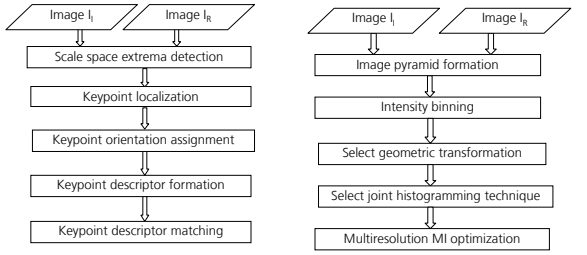

Figure 2: Methodologies for image to image registration.

3.2 Intensity Based Techniques

In intensity based registration, images are registered based on a relation between the intensity values of pixels of two images by reducing the registration process to a template matching scenario. The problem is mapped as an optimization scenario with the idea of maximizing a similarity metric between the two images. Two similarity metrics that have been utilized to register multimodal remote sensing images are cluster reward algorithm and mutual information (Inglada and Giros, 2004).

3.2.1 Mutual Information

Mutual information (MI) has evolved from the field of information theory. MI describes a statistical dependence between two images (e.g. A and B) expressed in terms of entropies.

$$MI(A,B) = H(A) + H(B) - H(A,B)$$

where H(A) and H(B) are the marginal Shannon entropies of A and B respectively and H(A, B) is the joint entropy of the variables. The entropy calculations are done using the estimated joint histogram (Suri and Reinartz, 2008). Inspired from its success for registration of multimodal medical images, remote sensing community has used it to solve the meticulous task of *registering SAR-Optical image pairs automatically*. The flowchart depicting the intensity based registration technique is visualized in Figure 2.

3.2.2 Limitations and Challenges

- Time complexity for huge remote sensing datasets can be a great overhead
- Normally utilized for rigid body transformation, which might not be able to accommodate the fine local deformations present within remote sensing images
- Adaptations needed for high resolution multi land cover satellite images.

References

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