Image Mosaicing and Registration

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***Abstract*— Image registration is the process of overlaying images (two or more) of the same scene taken at different times, from different viewpoints, and/or by different sensors. The registration geometrically aligns two images (the reference and sensed images). Many applications require a panoramic image of the object but due to limitation of apparatus, only a single image of the object in large scale can be captured from the global views. Therefore, a series of images of the object are collected with overlapped areas and mosaiced to construct a panorama which can be stored in files or databases and be viewed quickly.**

This project has been undertaken keeping in view that all imaging systems require some form of registration. A few examples are aligning medical images for diagnosis, matching stereo images to recover shape, comparing facial images in a database to recognize people etc. Given the difficulty of registering images taken at different times, using different sensors, from different positions, registration algorithms come in many different shapes and sizes. Given the wide range of imaging applications, there are many different types of registration algorithms. In this project we are using an algorithm based on Correlation.

For Automatic Image Registration Applications, we are detecting the features like edges by using Sobel Edge Detection Algorithm. For matching the features we are first Segmenting the image file in terms of different blocks and then applying the Hierarchical matching to create pyramid of block. Finally we are applying correlation based matching starting from the top level of pyramid.

For Image Mosaicing Applications, we have to find out the control points. For finding control points we have to find out overlapping portions in both left profile and right profile of image. If both left and right profile have sufficient part common then 1st perform Segmentation to divide the image in terms of block of data and then for matching developing pyramid of blocks by using Hierarchical matching. Otherwise take a suitable pixel block size say of 32 x 32 pixels block from right profile image and search for the exact location of that 32 x 32 pixels block in the left profile image.

Keywords**:** Sobel, Image Mosaicing, Feature Matching, Feature Detection.

I. Introduction

Image Registration is the process of overlaying two or more images of the same scene taken at different times, from different viewpoints, and/or by different sensors.

Image Mosaicing is the process of producing a seamless combined image from two or more images having significant overlap.

Many imaging applications require registration. Image registration involves finding a geometric transformation mapping one of the images to the other, usually for easy comparison. Given the wide range of imaging applications, there are many different types of registration algorithms. Recently, a new type of solution to the registration problem has emerged, based on information theory in the form of a mutual information similarity metric. The metric works from the pixel values and makes few assumptions about the surface properties of the object or the imaging process.

Multi-modal medical imaging was one of the original motivations for the mutual information registration systems. In many applications, a medical practitioner wants to view multiple sensor images to locate abnormalities and decide upon a treatment plan. For instance, in radiotherapy the initial detection is often based on one of the functional scans, such as Single Photon Emission Computed Tomography (SPECT) or Positron Emission Tomography (PET). Subsequently, the outlining of the tumor is based on the Magnetic Resonance scan (MR), and the dosage is based on a Computed Tomography (CT) scan.

The increased volume of satellite images has reinforced the need for automatic image registration methods. Several techniques for automatic image registration have been developed. Since the performance of a methodology is dependent on specific application, sensor characteristics and the nature and composition of the imaged area, it is unlikely that a single registration scheme will work satisfactorily for all different applications. The main goal of this work is to bring developed registration methods into one automatic image registration system and to make them work operationally. Information provided by the user is used to assist in the registration process.

II. Literature Survey

The first computers powerful enough to capture images appeared in the 1960s. The birth of what we can digital image processing today can be traced to the availability of those machines and the onset of the space program during that period. On July 31, 1964 the first image of the moon was taken by the Ranger & at 9:09 A.M. The imaging lessons learned with Ranger & served as the basis for improved methods used to enhance and restore images from the other lunar missions like Surveyor, Mariner etc.

In parallel with the space applications, images were captured and analyzed in the late 1960s and 1970s for medical imaging, remote Earth resource observation and astronomy.

In the 1970s the invention of CAT or the computer axial tomography is one of the most important events in the application of image processing for medical diagnosis. Tomography was invented independently by Sir Godfrey N. Housinfield and Professor Allan Comrack who shared the Nobel Prize in Medicine in 1979. It is interesting to note that x-rays were discovered in1895. These two inventions have led to some of the most active applications areas of automatic target detection and recognition today.
Recent advances in satellite technology have resulted in imaging techniques beyond ones imagination.

A. Edge Detection

Edges characterize boundaries and are therefore a problem of fundamental importance in image processing. Edges in images are areas with strong intensity contrasts – a jump in intensity from one pixel to the next. Edge detecting an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. There are many ways to perform edge detection. However, the majority of different methods may be grouped into two categories, gradient and Laplacian. The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image. The Laplacian method searches for zero crossings in the second derivative of the image to find edges. An edge has the one-dimensional shape of a ramp and calculating the derivative of the image can highlight its location. Suppose we have the following signal, with an edge shown by the jump in intensity below:

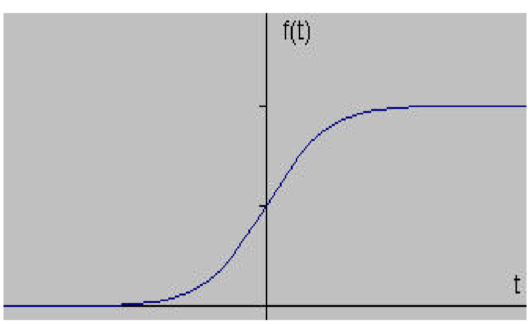


Fig. 1. Input Signals

If we take the gradient of this signal (which, in one dimension, is just the first derivative With respect to t) we get the following:

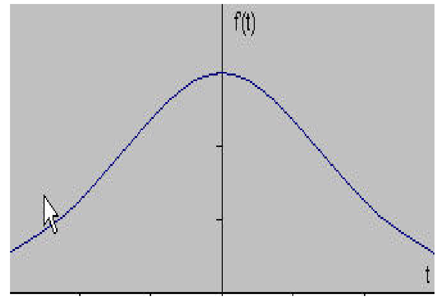


Fig. 2. *1st derivative of Input Signal*

Clearly, the derivative shows a maximum located at the centre of the edge in the original signal. This method of locating an edge is characteristic of the “gradient filter” family of edge detection filters and includes the Sobel method. A pixel location is declared an edge location if the value of the gradient exceeds some threshold. As mentioned before, edges will have higher pixel intensity values than those surrounding it. So once a threshold is set, you can compare the gradient value to the threshold value and detect an edge whenever the threshold is exceeded. Furthermore, when the first derivative is at a maximum, the second derivative is zero. As a result, another alternative to finding the location of an edge is to locate the zeros in the second derivative. This method is known as the Laplacian and the second derivative of the signal is shown below:

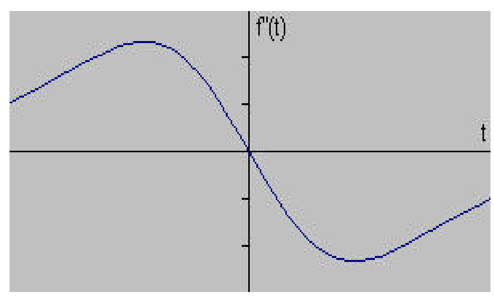


Fig. 3. 2nd Derivatives of Input Signal

B. Sobel Algorithm

Based on this one-dimensional analysis, the theory can be carried over to two-dimensions as long as there is an accurate approximation to calculate the derivative of a two-dimensional image. The Sobel operator performs a 2-D spatial gradient measurement on an image. Typically it is used to find the approximate absolute gradient magnitude at each point in an input gray scale image. The Sobel edge detector uses a pair of 3x3 convolution masks, one estimating the gradient in the x-direction (columns) and the other estimating the gradient in the y-direction (rows). A convolution mask is usually much smaller than the actual image. As a result, the mask is slid over the image, manipulating a square of pixels at a time. The actual Sobel masks are shown below:

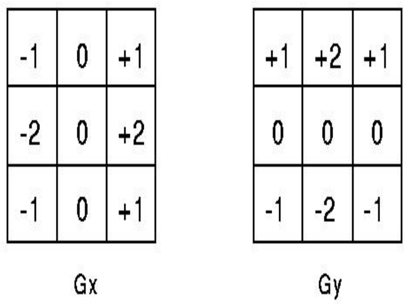


Fig. 4. Gradient Matrix in the Direction of x and y

The magnitude of the gradient is then calculated using the formula:

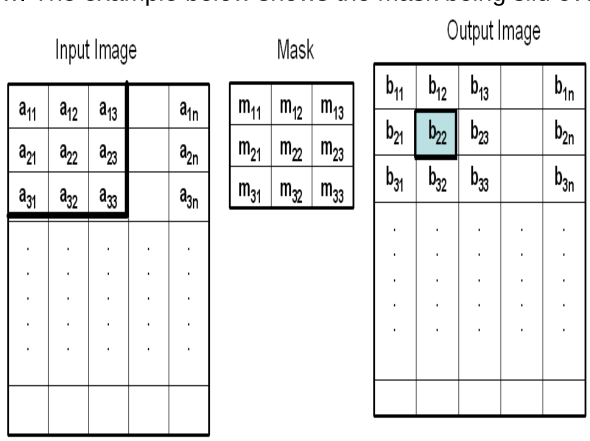
$$|G| = \sqrt{Gx^2 + Gy^2}$$

An approximate magnitude can be calculated using:

$$|G| = |Gx| + |Gy|$$

1) Sobel Explanation

The mask is slid over an area of the input image, changes that pixel's value and then shifts one pixel to the right and continues to the right until it reaches the end of a row. It then starts at the beginning of the next row. The example below shows the mask being slid over



the top left portion of the input image represented by the dark outline.

$b_{22}= (a_{11}*m_{11})+(a_{12}*m_{12})+(a_{13}*m_{13})+(a_{21}*m_{21})+(a_{21}*m_{21}) + (a_{22}*m_{22})+ (a_{23}*m_{23})+ (a_{31}*m_{31})+ (a_{32}*m_{32})+ (a_{33}*m_{33})$

The formula shows how a particular pixel in the output image would be calculated. The centre of the mask is placed over the pixel you are manipulating in the image. I & J values are used to move the file pointer so you can multiply, for example, pixel (a22) by the corresponding mask value (m22). It is important to notice that pixels in the first and last rows, as well as the first and last columns cannot be manipulated by a 3x3 mask. This is because when placing the centre of the mask over a pixel in the first row (for example), the mask will be outside the image boundaries.

The GX mask highlights the edges in the horizontal direction while the GY mask highlights the edges in the vertical direction. After taking the magnitude of both, the resulting output detects edges in both directions.

C. Hierarchical Matching Technique

Image matching can be done in two ways

1) ***Interactive:*** Generally softcopy workstations offer tools for manual or interactive measurements of conjugate (tie) points. In this process the operator selects the tie point in one image and the computer performs the matching. Interactive methods especially mimic the way DEM generation in analytical mode is performed on analytical plotters. An advantage of the interactive mode is of a practical nature. Users may follow familiar procedures and reducing the risk of making mistakes. But the disadvantage is the time involved in generating a set of conjugate points, which is too high.

2) ***Automatic:*** In the automatic mode, point selection and measurement are done automatically. There are different methodologies available in literature for finding conjugate points from a pair of stereo images in automatic mode, which include decision sequencing, relaxation, dynamic programming, generalized Hough transform, linear programming, hierarchical representation, tree and graph matching.

Hierarchical Matching technique is most widely used approach of all. This method has an advantage of improving and speeding up many different approaches by guiding search through progressively finer resolution. Objects represented in the image space vary enormously in size and extend. In order to identify and qualitatively describe events in the object space, it is necessary to evaluate and combine the image at different scales, a procedure known as the multi-space technique. Smoothing the original image with a low pass filter of varying size results in images at various scales (levels of hierarchy).At each scale, the corresponding images are called image pyramids. Selection of the optimal number of pyramids depends on the viewing angle of the stereo pair used, terrain undulations and the seed point selection in the matching process. After forming the image pyramids hierarchical matching uses four basic steps at each level to get the final match at the lowest level.

1) Interest point (candidate) identification
2) Local mapping between stereo images
3) Digital Correlation up to sub- pixel accuracy
4) Blunder Detection

1) Candidate Feature Selection

At the highest level of the pyramid the seed points are identified manually or through an interest operator on reference image and blind correlation of these points in the other image. A good feature extraction is a reliable pre-processing step for good image matching. Therefore selecting good features and providing reliable and accurate approximate values for succeeding fine correlation attracts ever-increasing interest. At each point, the four gradients to the neighboring pixels are calculated.

2) Local Mapping

This is done by establishing a local transformation between reference image and the second image of the stereo pair for each interest point located in the reference image. At each level first interest operator is obtained to get some candidate points for matching. Local mapping using the previous level's match point establishes a correspondence with the second image for all interest points in the second image.

Similarity Measures

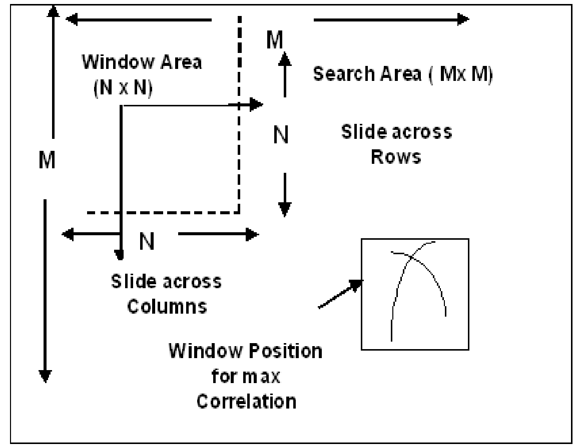
The basic correlation techniques can be classified into three categories.

- Area Based
- Feature Based
- Symbolic

Area based matching is associated with matching grey levels – grey level distribution as small areas of two images, call image patches (windows and search areas) is compared and similarity is measured by correlation or least square techniques. The features used as matching entities in feature based matching are derived from the original image. The feature can be edge, corner etc. The third method, symbolic matching, compares symbolic description of images and measures the similarity by a cost function. The symbolic descriptions may refer to grey values or to derive features.

A. Digital Cross Correlation

Cross-correlation is the basic statistical approach for image matching. It is often used for template matching or pattern recognition in which the location and orientation of a template or pattern is found in an image. Cross correlation is a similarity measure or match metric, i.e. it gives the degree of similarity between an image and a template. The process of template matching is shown in the following figure:



$$R = \frac{\sum_{x=1}^{N} \sum_{y=1}^{N} s(x,y)\, w(x,y)}{\left[\sum_{x=1}^{N} \sum_{y=1}^{N} s(x,y)^2 \sum_{x=1}^{N} \sum_{y=1}^{N} w(x,y)^2 \right]^{1/2}}$$

Where s(x, y) and w(x, y) are pixel values at location (x, y) of s and w respectively, The value of R changes between 0 and +1 and the closer R is to +1, the more similar the two windows will be. If the value of R is near 1 this means that the both reference and sensed image have similar kind of features. If the value of R is near 0 this means that the both reference and sensed image have different kind of features. If it's between 0 and 1 this indicates that both reference and sensed image have some common features. We are setting critical value for R as .95 but it is dependent on several parameter i.e. intensity value and pixel representation.

B. Blunder Detection

A decision can be taken, whether a point is matched or not by the correlation coefficient magnitude. The correlation coefficient 1 indicates a perfect match and the window and search areas are extracted from same images. However this will not happen anytime, since the image chips used are from different images taken different times. Hence always the correlation coefficient is less than 1. But a threshold can be fixed on correlation coefficient (> 0.5) to identify the probable match point.

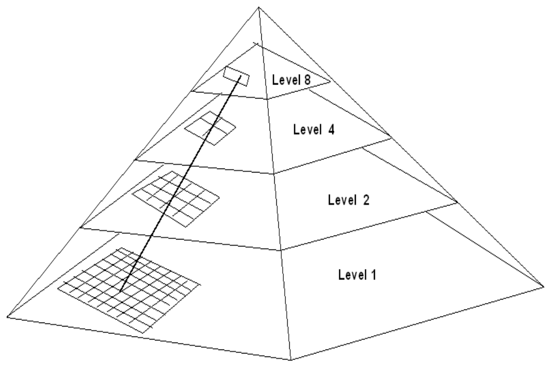


Fig . 6 : Image pyramid as a representation of the discrete scale space

In Fig 6, we explain the formation of pyramid in the block of pixel representation of data. We will start from lower level in the block and go on dividing until we get 4 x 4 as highest level. Once we get 4 x 4 blocks then we stop dividing and that is the required block for finding out correlation. Here we are dividing the block image in terms of different hierarchy of levels and we start searching similarities from top of hierarchy to bottom of hierarchy. searching similarities from top of hierarchy to bottom of hierarchy.

III. Methodology

Image registration, as it was mentioned above, is widely used in remote sensing, medical imaging, computer vision etc. In general, its applications can be divided into four main groups according to the manner of the image acquisition.

Applications can be divided into four main groups according to the manner of the image acquisition:

1) Different viewpoints (Multiview analysis)

Images of the same scene are acquired from different viewpoints.
Aim: To gain larger a 2D view or a 3D representation of the scanned scene.
Examples of applications: Remote sensing—mosaicing of images of the surveyed area

2) Different times (Multitemporal analysis)

Images of the same scene are acquired at different times, often on regular basis, and possibly under different conditions.
Aim: To find and evaluate changes in the scene which appeared between the consecutive images acquisitions.
Examples of applications: Remote sensing—monitoring of global land usage, landscape planning.

3) Different sensors (multimodal analysis)

Images of the same scene are acquired by different sensors.
Aim: To integrate the information obtained from different source streams to gain more complex and detailed scene representation.
Examples of applications:
Remote sensing—fusion of information from sensors with different characteristics like panchromatic images, offering better spatial resolution, color/multispectral images with better spectral resolution, or radar images independent of cloud cover and solar illumination.

4) Scene to model registration

Images of a scene and a model of the scene are registered. The model can be a computer representation of the scene, for instance maps or digital elevation models (DEM) in GIS, another scene with similar content (another patient), ‘average’ specimen, etc.
Aim: To localize the acquired image in the scene/model and/or to compare them.
Examples of applications:
Remote sensing—registration of aerial or satellite data into maps or other GIS layer

A. Image Registration method

Due to the diversity of images to be registered and due to various types of degradations it is impossible to design a universal method applicable to all registration tasks. Every method should take into account not only the assumed type of geometric deformation between the images but also radiometric deformations and noise corruption, required registration accuracy and application-dependent data characteristics. Nevertheless, the majority of the registration methods consist of the following four steps:

1) Feature Detection

Salient and distinctive objects (closed-boundary regions, edges, contours, line intersections, corners, etc.) are manually or, preferably, automatically detected. For further processing, these features can be represented by their point representatives (centers of gravity, line endings, distinctive points), which are called control points (CPs) in the literature.

2) Feature matching

In this step, the correspondence between the features detected in the sensed image and those detected in the reference image is established. Various feature descriptors and similarity measures along with spatial relationships among the features are used for that purpose.

3) Transform model estimation

The type and parameters of the so-called mapping functions, aligning the sensed image with the reference image, are estimated. The parameters of the mapping functions are computed by means of the established feature correspondence.

IJCSI International Journal of Computer Science Issues, Vol. 10, Issue 2, No 1, March 2013
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org

4) Image resampling and transformation

The sensed image is transformed by means of the mapping functions. Image values in non-integer coordinates are computed by the appropriate interpolation technique.

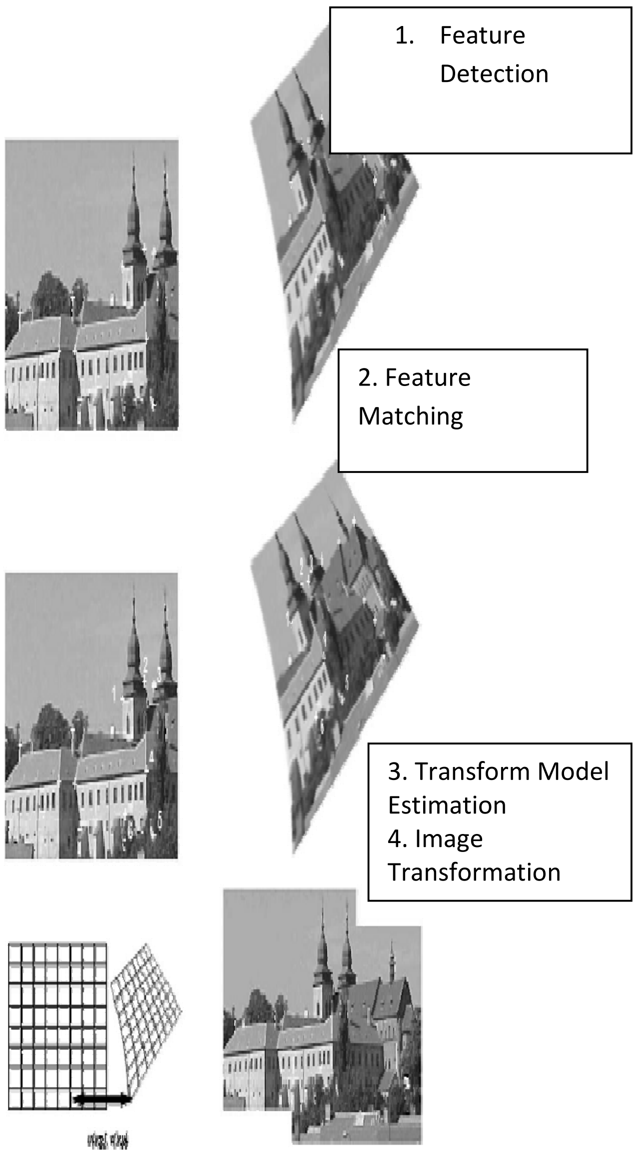


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Fig. .7 Example of image registration & mosaicing

Four steps of image registration:

a. Top row—feature detection (corners were used as the features in this case).
b. Middle row—feature matching by invariant descriptors (the corresponding pairs are marked by numbers).
c. Bottom left—transforms model estimation exploiting the established correspondence.
d. Bottom right—image resampling and transformation is using appropriate interpolation technique.

IV. IMPLEMENTATION AND RESULT

Programming Language: ANSI C is used to implement, Tools Used: JAVA IDE for Front End

Fig. 8. Output : Image Mosaiced

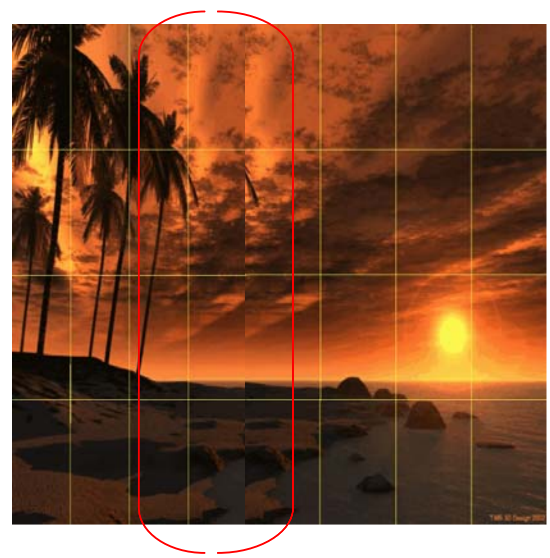

Fig. 9. Input : Two Separate Images

V. CONCLUSION

In the algorithm discussed above, registration process is required if the input images are not aligned. For properly aligned images registration and correlation is not required. Directly mosaicing can be applied. For Automatic Image Registration Applications, we are detecting the features like edges by using Sobel Edge Detection Algorithm. For matching the features we are first Segmenting the image file in terms of different blocks and then applying the Hierarchical matching to create pyramid of block. Finally we are applying correlation based matching starting from the top level of pyramid.

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