IACSIT International Journal of Engineering and Technology, Vol.2, No.3, June 2010
ISSN: 1793-8236

Computation of Geographic Location with the Aid of Geospatial Images

Ameya Gawde, Gresha Bhatia, Daishik Mehta, Hitesh Rohira and Aniket Phatak

***Abstract*—A Geographic Information System (GIS) is any information system that integrates stores, edits, analyzes, shares, and displays geographic information. In a more generic sense, GIS applications are tools that allow users to create interactive queries (user created searches), analyze spatial information, edit data, maps, and present the results of all these operations. Pattern matching is a technique in which the location of a particular place is found by comparing its raw image with the image present in the database. It checks the presence of certain structure in an image. It is done between the reference image and database images, sequentially, pixel by pixel. In this paper, we provide a system which makes use of various data mining algorithms and pattern matching techniques to reduce the impact of disturbances in images using affine and asymmetric transformations. We have assumed some aspects in the input image such as only spatial datasets from different sources are considered. Secondly, a minimum threshold resolution of images is required which is determined in advance. Moreover, we perform pattern matching on point data by using FFT algorithm.**

***Index Terms*—Georefrencing; GIS; Segmentation; Registration.**

I. INTRODUCTION

Georeferencing is one of the vital research areas of GIS data integration literature. So, it is essential to explore this aspect and work more in this field. Geospatial information needs to be extracted from multiple sources in a very consistent and precise way.

Georeferencing helps in defining actual existence in physical space. The location is determined in terms of its mapping projections or world coordinate system. The relation between raster images and coordinate system is established by georeferencing. Other geographical features' spatial location can also be found out using georeferencing. Most of the cartographic methods and geographic information systems (GIS). Many a times it happens that data collected for analysis is from different sources. Thus, it becomes imperative to have common referencing systems.

The typical Georeferencing process includes:

a. Identifying a set of control point pairs that link locations on a raster image with corresponding locations on a correctly positioned vector dataset.

b. Calculating a transformation function from a raster image to the vector map based on the Control Point Pairs (CPPs).

c. Finally, transforming and re-sampling the image.

First step is usually a manual process and hence time consuming. It requires user to have a substantial knowledge about the geographical location of the raster image in order to manually establish CPPs. This process takes more time and is also prone to errors and it is sometimes impossible to find CPPs manually. Hence we are using automated Georeferencing of raster image to vector image under similarity and affine transformations. Automated Georeferencing eliminates the same scene constraint between an image and the vector network. It also requires less number of points for comparison. It also provides high performance and scalability.

Pattern matching is the act of testing for the availability of certain parameters of a given pattern. Pattern matching is used to check the presence of certain structure in an image. It is done between the reference image and database images sequentially pixel by pixel.

Pattern matching in GIS is a system which would help to identify and find locations easily via Data Mining techniques. Various other papers in this area have the limitations in respects that they reject their scope to affine transformations and asymmetric segmentations. This has led us to design our system which includes the aforesaid transformations and segmentations.

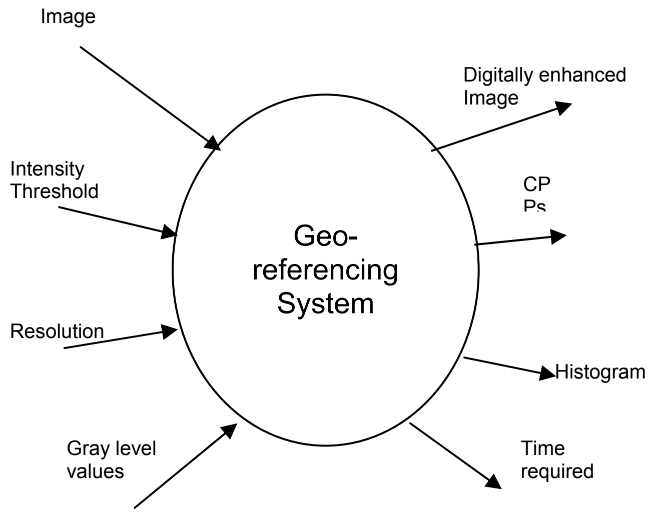

Fig 1 System Diagram

The above figure (Fig 1) denotes the basic inputs and outputs of the system. Geo-referencing system would require image; intensity threshold; resolution and gray level values as its input. The resulting output would be digitally enhanced image, control point pairs (CPPs), histogram and time required to carry out the required entire process.

There are various stages in our project, namely, Image Enhancement Pre-processing, Image Segmentation, Image Registration, Feature Detection, Feature Matching, Affine and Similarity transformations and Image Enhancement Post-processing. We also maintain an Image Database wherein we store different images in different formats, namely, JPEG, GIF, etc to be compared with the input image. This comparison is done for specific satellite images using highly efficient pattern matching algorithms. Each of the individual modules are described in detail using their data flow diagrams.

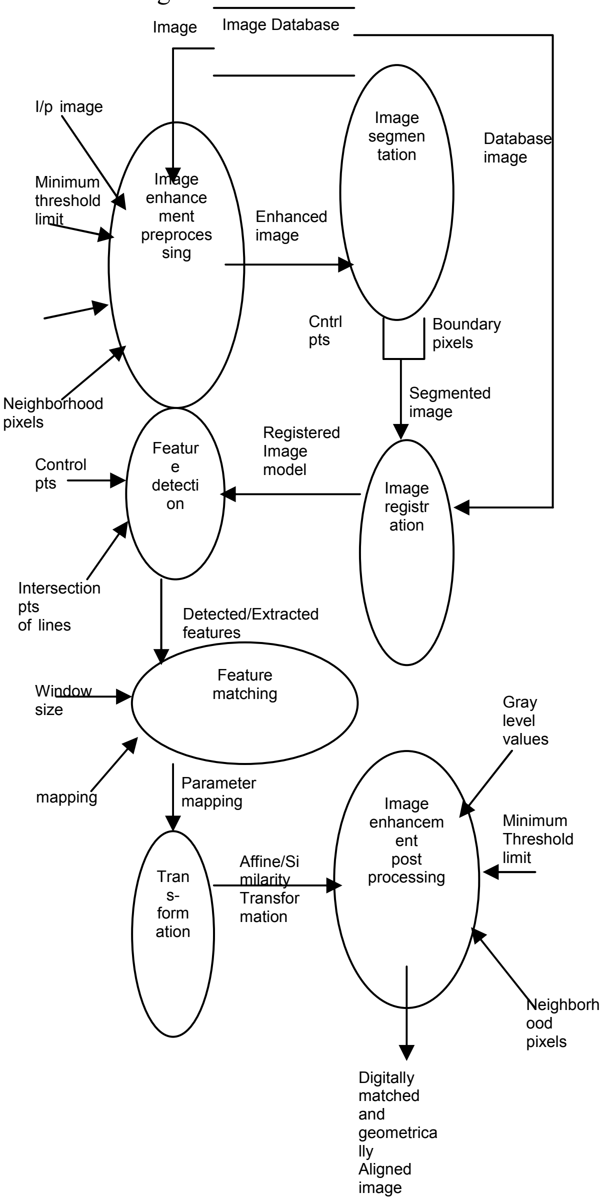

Fig 2 Georefencing system

The various inputs taken in the system and outputs of the system are illustrated by the Figure 1. The inputs are input image, minimum threshold limit of intensity required for different modules in the system, resolution of the input image and gray level values. The final output of the system will be geometrically aligned and matched image to the particular image in the database. Also, various other analysis outputs are given, namely, matching and verification time with respect to number of control points. Also, outputs are presented in various forms like histogram, graphs and reports.

II. Image Enhancement (pre- processing):

Image Enhancement is the process by which an image is manipulated to increase the amount of information perceivable by the human eye. It takes in various input parameters like neighborhood pixels, intensity, gray level values and gives the enhanced (smoothened) image as output. The algorithm used for this is shown below.

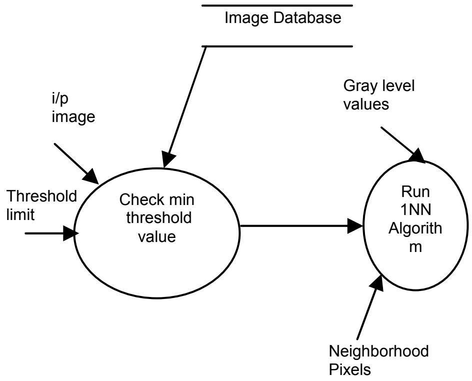

Fig 3 Image Enhancement

The first module in our system is preprocessing of images using enhancement techniques. Image enhancement is implemented using enhancement algorithm. In this algorithm we first determine the nearest neighbors, calculate the distance between query instance and all training samples of the point. Then, we sort the distance, determine the nearest neighbor and find values of the vertical distances of nearest neighbors. We use average of nearest neighbors as the prediction value of the query instance. The smoothing estimate is this arithmetic average of the values of the nearest neighbor. Also methods like contrast stretching, zooming, histogram equalization etc are performed for image enhancement.

III. Image Segmentation

Image Segmentation is the process of partitioning the image into non overlapping regions according to gray level, texture etc. Image Segmentation is the second module in our system and the algorithm used for image segmentation is shown below.

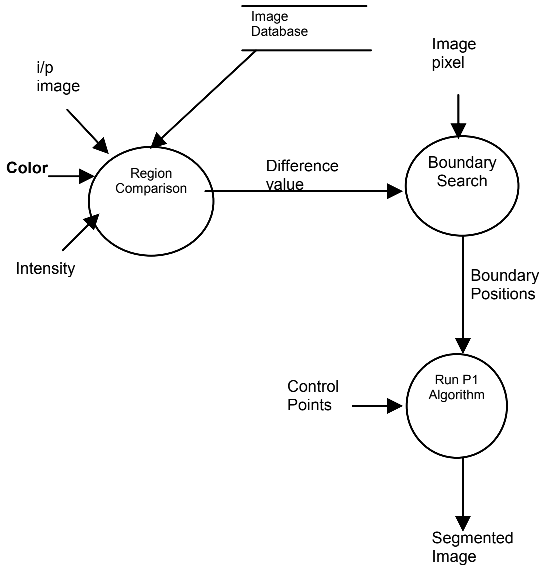

Fig 4. Image Segmentation

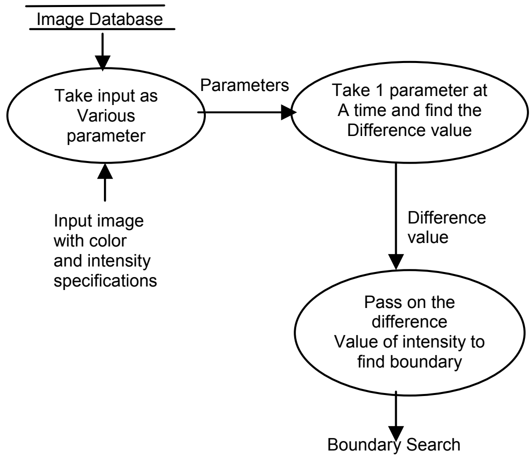

Fig 5 Boundary Search

Image segmentation is done using an algorithm which is based on Prim's algorithm. Like Prim's algorithm even this algorithm uses a single priority queue. In this algorithm, when a component stops growing the new source is set to the vertex with the minimum key in the priority queue. The above variation violates the minimum requirement of the algorithm to produce a segmentation which is not too coarse. Nevertheless, the quality of the output segmentation is good and running time is excellent. For adjacency matrix the time complexity of this algorithm would be O(N2) and if binary heap implementation is used complexity would be O((N+E) logN); Fibonacci heap implementation would result in complexity of O(E+NlogN) where 'N' is the number of vertices and 'E' is the number of edges.

IV. IMAGE REGISTRATION

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. It geometrically aligns two images- the referenced image and the sensed image.

Our proposed system uses scene to model image registration method. Images of a model and a scene of the model are registered. This model is used as it is well suited for registration of satellite data into maps or other GIS layers.

Image Registration for point data is performed using image to model registration. The process flow for the image to model registration is shown in figure 3. Image Registration includes Feature Detection, Feature Matching and geometric transformations. Within this process, the features are extracted in the image domain and are matched with the corresponding features of the image in the database. The objective is to generate an association across these two extracted sets to establish tie points. This is performed using Feature Matching and then geometrically transforming the matched features.

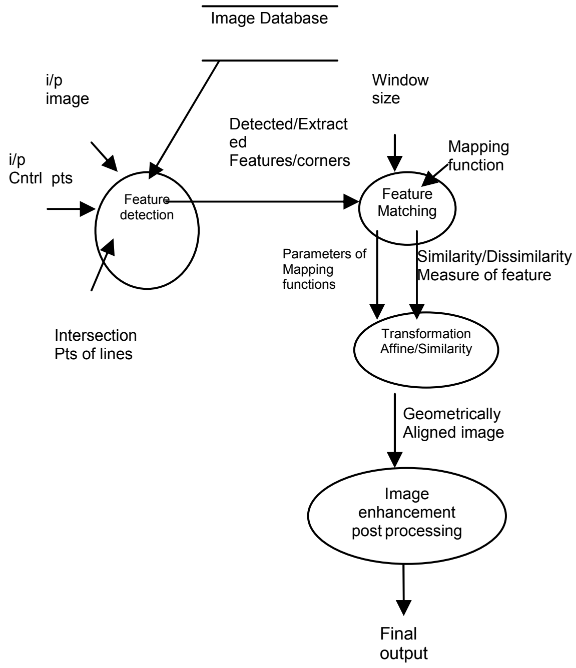

Fig 6 Image Registration Flowchart

Feature Detection is the processing of raw data to assess the presence of a given attribute (property). In this system Feature Detection is performed on point data. Feature Detection is performed using corner detection algorithm. For this the cornerness map of the input image is calculated. The result of this calculation is an image where corner areas are having brighter than the flat area intensity. The corner response of the algorithm would depend on the value of a threshold function which is calculated using intensity values. After this the corner areas are separated into isolated regions and local maximum is calculated. These maxima points are he searched corner points. Thus detected feature is the output.

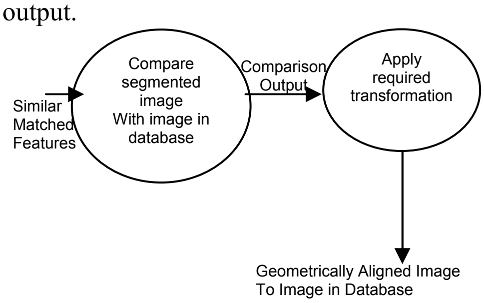

Fig 7 Transformation

The feature detected from the above algorithm is then matched with the database image.

Feature Matching is the process by which a correspondence is established between the detected feature of the input image and the reference image. Feature matching is performed using another algorithm. Let us consider that the two images differ by shift to and scaling s for which x'(t)=x(st-t0) . Now Fourier transform is applied to the signals x(t) and x'(t). Their Fourier transform is F(w) and F'(w) respectively. Now the magnitudes M(w) = F(w) and M'(w) = F'(w) is computed. Now the scaling detection algorithm is applied to the functions M (w) and M'(w) determine the scaling factor s.

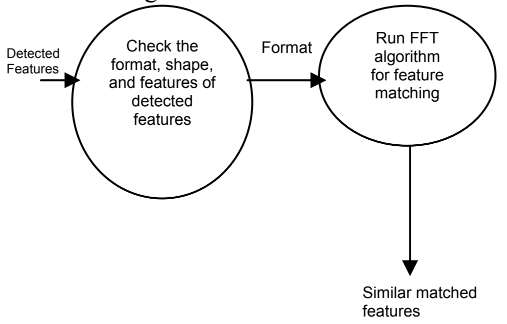

Fig 8 Feature Matching

Now Scaling is reduced to Shift by transforming both the images i.e. the input image and the image from the database from the original frequencies to the log frequencies. Now the shift detection algorithm is used to determine the corresponding shift log(s). From the corresponding shift values, the scaling coefficient s is reconstructed. For shift detection algorithm we apply Fast Fourier Transform to the original signals x(t) and x'(t) and compute their Fourier Transforms F(w) and F'(w). We then compute the product p(w) =F*(w).F'(w) and the ratio R(w)=p(w)/|p(w)|. Now we apply inverse Fourier Transform to the ratio R(w) and compute its Fourier Transform I(t). We then determine the desired shift to as the point at which the magnitude| I(t0)| attains largest possible value. Then we apply the corresponding scaling X(t); as a result, we get a new signal X1(t). The signals X(t) and X1(t) are already aligned in terms of scaling, the only difference in them is an unknown shift, so we again apply the above FFT based algorithm for determining shift, this time, actually to determine shift.

Time complexity of this algorithm is of the order of O (n log n).

The final stage of image registration is geometrically aligning the input image with the database image. For geometrically aligning the images various similarity and Affine transformations are performed. Similarity transformation would include following operations:

i) Rotation.
ii) Translation.
iii) Scaling.

Affine Transformation would comprise of:

i) Rotation.
ii) Scaling.
iii) Translation.
iv) Skew.

After performing these transformations, the input image and the database image is geometrically aligned.

V. Image Enhancement (post-processing)

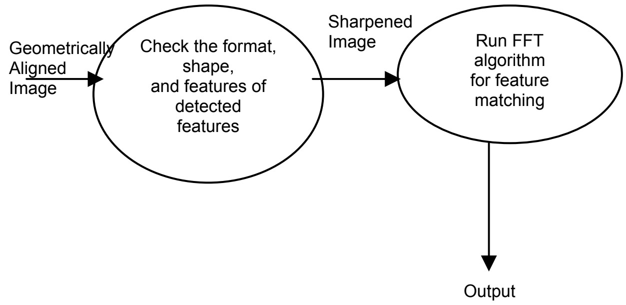

Fig 9 Image Enhancement

The geometrically aligned image obtained from the registration phase is given as an input to Image Post Processing phase which is responsible for image enhancement. This phase includes sharpening and median filter, region location and time analysis.

Median filter is a non-linear digital filtering technique which is used for noise reduction and edge detection. It is particularly used to combat speckle noise and salt pepper noise. The steps involved are:

a) Store the neighboring pixels in an array of odd size called window.
b) Sort the window numerically.
c) Select the median from the window as pixels value.

Sharpening filters are used to enhance the object-edges. Thus used as edge-detectors. They also adjust contrast and shade characteristics. Like high pass filters, they are used to allow high frequencies to pass and block low frequencies. Also they are sensitive to shut noise.

In Region Location phase, the region in the filtered image is located. Time Analysis phase would give the time required to perform the operation.

VI. Conclusion

The paper has proposed an approach for pattern matching of geospatial data. The technique for pattern matching presented in this paper can be further extended for lines, curves, regions and contours. The algorithm specially designed for this condition would prove more efficient than the point processing one used in this paper. Further advancements can be implemented by making the system have the prior knowledge of the minimum threshold which is an important input to the current system.

Inference: Certain domains like Asymmetric Segmentation and Affine Transformations have also been considered using suitable algorithms. The accuracy of the system is in proportion with the number of control points pairs been computed.

References

[1] Digital Image Processing using matlab by Gonzalez, Woods and Effins
[2] Digital Image Processing by Rafael C Gonzalez and Effins
[3] Master Project: Pattern Matching in GIS
[4] GIS Pattern Recognition and Rejection Analysis Using MATLAB
[5] Image registration - Wikipedia, the free encyclopedia.
[6] Image Processing and Image Enhancement- Wikipedia, the free encyclopedia.

[7] Data Mining by Han Kamber.

Ameya Gawde has completed Bachelor of Engineering in Computer Engineering from Vivekanand Education Society's Institute of Technology, Mumbai in 2010. He is currently pursuing MS in Computer Science at University of California, Los Angeles. He can be contacted at gawde.ameya@gmail.com.

Gresha Bhatia is an assistant professor in Department of Computer Engineering at Vivekanand Education Society's Institute of Technology, Mumbai. She can be contacted at itsgresha@yahoo.co.in.

Daishik Mehta has completed Bachelor of Engineering in Computer Engineering from Vivekanand Education Society's Institute of Technology, Mumbai in 2010. He can be contacted at daishik.mehta@gmail.com.

Hitesh Rohira has completed Bachelor of Engineering in Computer Engineering from Vivekanand Education Society's Institute of Technology, Mumbai in 2010. He can be contacted at rohira.hitesh@gmail.com.

Aniket Phatak has completed Bachelor of Engineering in Computer Engineering from Vivekanand Education Society's Institute of Technology, Mumbai in 2010. He is currently pursuing MS in Computer Science at Columbia University, NY. He can be contacted at phatakaniket@gmail.com.