Improvised Interpolation of Contour Lines Using Spider Weaving Approach

Mohan P Pradhan
Dept. of CSE, SMIT, SMU
Sikkim, India
mohanp_pradhan25@ yahoo.com.sg

M K Ghose
Dept. of CSE, SMIT, SMU
Sikkim, India
mkghose@smu.edu.in

***Abstract*—Geographically contours are virtual lines drawn across the terrain to join points that are at same elevation from certain reference point. Contours are essential morphological features that are used along with the associated elevation as basis for generating Terrain Model or Digital Elevation Model for the area of interest. These lines are represented at different scales depending upon the scale of data representation. The smoothness of the elevation model derived from these contours always depends on the number of contour lines covering the terrain. If there is lesser number of contour lines covering the terrain then the elevation model would rather appear sharp where as on the contrary if the number of line covering the terrain is more than the terrain would rather appear smooth. Further it implies that in order to create a smooth terrain from a set of contours, either contour map with smaller scale should be taken into consideration or efficient interpolation algorithms should be designed. Terrains for which small scale maps are not available the later proves effective. This research initiative aims at designing an efficient algorithm for determining reduced set of interpolation points for generating intermediate contours based on the concept of angular directional movement acquiring knowledge from weaving approach deployed by Spider.**

Keywords- Angular Directional Movement, Digital Elevation Model, Elevation, Stair Case, Spider Web.

I. INTRODUCTION

Smoothness or sharpness of the elevation model pertaining to a terrain greatly depends on the inter-contour separation. Greater the inter-contour separation more the sharpness whereas lesser the inter-contour distance greater will be the smoothness of the elevation model for the same terrain. So morphological studies conducted on the basis of elevation model created from the former and from the later may lead to ambiguous inferences. It implies that the elevation model greatly differs with scale at which the features are represented.

A topological map pertaining to landscape incorporates different types of morphological features. To name a few the feature set includes water bodies such as rivers and lakes, landscapes features such as contours, transportation networks such as roads and text features such as elevation detail of a contour, names of rivers, names of landmarks etc. Each of these morphological features for the ease of visual interpretation is represented using different color code.

Manual extraction or digitization of the features can be easily done by acquiring knowledge regarding the color code used for representation where as designing an automated process includes designing a segmentation scheme based on the range of intensity values the features.

One such feature of interest is contour. Contours can be classified as complete ridge, incomplete ridge, short ridge and enclosure etc. Along with each the contour line or at certain intervals elevation detail is associated. This elevation detail is used along with the contour to create a 3D model of a landscape. This 3D model of the landscape is called DEM (Digital elevation Model), which are used for inferential studies related to morphological features. The smoothness of the terrain represented in DEM depends on the number of contour lines used in-order to create the same.

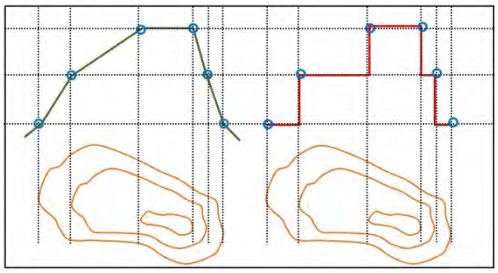


Figure 1: DEM created from a large scale image [11]

Figure 1 presents an example of DEM created from a large scale image where due to greater inter-contour distance, there is less variation in slope leading to a sharper DEM.

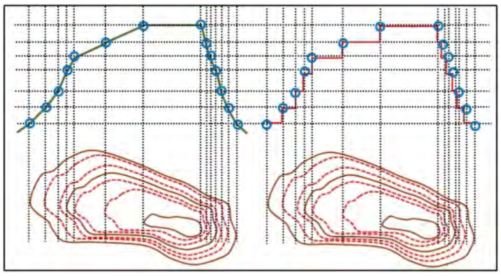


Figure 2: DEM created from a small scale image [11]

Figure 2 presents an example of DEM created from a small scale image where due to smaller inter-contour distance, there is greater variation in slope leading to a smoother DEM.

By analyzing the two examples it can be further concluded that 3D elevation of contours for creating DEM would lead to creation of stair case. The size of the stair case is directly proportional to the scale of the image - small scale image has smaller stair size and large scale image has greater stair size as shown in Figure 3.

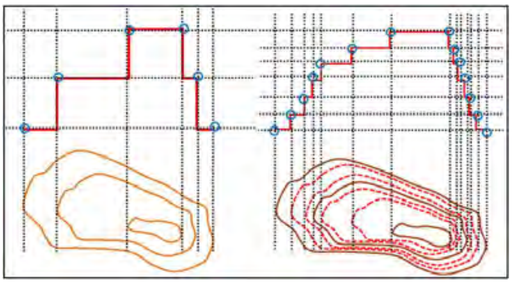


Figure 3: Creation of stair case [11]

So for creating a smooth DEM the stair size has to be reduced. This can be achieved by using either a small scale image or an effective interpolation algorithm can be developed for the same. Landscape for which small scale map exist the former provides the best solution where as in situations where availability, accessibility of small scale map is questionable then the later proves to be more effective.

Knowledge from nature and its interpretation can be used as basis for formulation solution.

One such object of interest is spider web. The spider webs created by a spider are of different types viz; Tangle Webs or Cobwebs, Funnel Webs, Tabular Web and Sheet Web. Structure threads and the radial spiral threads are two important components. The structural threads are placed in a manner that they do not overlap. Upon creating a stable structure the spider start radial spiral traversal to create the radial web. While creating a web spider follows the following steps

- Initially spider creates a thread, fixes one of its end to a stable surface band and lets loose the other patiently waiting for breeze to carry the other end so that it stick to the surface as shown in Figure 4(a).
- After the loose end catches hold of the surface, the spider uses it to now create additional threads to stabilize the structure Figure 4(b).
- The supporting threads are placed at locations where there is considerable chance in the angle Figure 4(c).
- On completing the support structure as in Figure 4(d) the spider starts radial traversal for weaving the web.

- The spider travels radially inside out for completing the web. While travelling radially the threads are placed at equidistance to prevent overlapping.

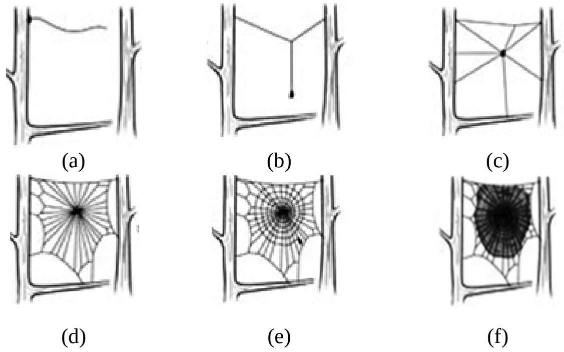


Figure 4: Weaving strategy under taken by the spider. [14]

Following the spider web concept, this work aims at determining interpolation points as per following steps:

- improvised angular direction movement strategy based on types of minutiae for creating the structure
- generation of interpolated points from the structure threads
- joining the interpolated points using the weaving strategy to create interpolated lines between the identified contour lines

In abstraction, this work can be decomposed into following identifiable steps,

- Segmentation for identifying contour feature
- Thinning of segmented contour feature for representing the feature using single pixel width
- Identification of Minutiae's using spiral navigation
- Creation of angular movement mask
- Assignment of angular movement mask
- Creating of ridges for angular movement based on dissimilarity of angular mask assigned to the coordinate
- Resolve intersection of ridges
- Resolve hit and miss
- Interpolate points in the ridges
- Joining of interpolated points using weaving strategy of spider.

For optimal use of memory space the data structures used in this algorithm are jazzed in nature.

In addition reconnection of interpolated points was done using Bresenham's line drawing algorithm. Bresenham's line drawing algorithm was selected for drawing line as it performs integer arithmetic relying on simple arithmetic operation such as addition and subtraction resulting in faster line creation; it is capable of efficiently plotting curves with greater degree of accuracy as compared to that of other line drawing algorithms.

II. RELATED WORK

The accuracy of the process of interpolating line between existing contours would highly depend on firstly how efficiently the interpolated points in the interpolated line are determined and how efficiently a fitting curve is used in order to join the interpolated points that have morphological resemblance with contours. Interpolation is essential for creating a smooth DEM of the terrain. Two essential features required for converting contour map into DEM are sampling density along the contour and interpolating point in the grid [1]. Qing Wang et. al. [2] stated that methods for interpolating line between existing contours may be based on the knowledge of either edge-direction or direction guidance or orientation information of contours etc. Utilization of orientation information of the subset of the contour along with directional approach performs better interpolation than that of bi-cubic and bi-linear interpolation. Jianyun Chai et. al. [3] proposed a process for generating intermediate polygon terrain surface by formulating partial differential equations governing height along with gradient conditions taking into consideration smooth contours. Michael B Gousie [4] discussed a process for determining the intermediate point by using successive sub division process where adjacent contour lines at different elevation were taken into consideration and the midpoint was determined taking into consideration the direction of slope. Colin Childs [5] stated that there are basically two categories of interpolation technique based on deterministic approach and geo-statistics. Deterministic approaches are based on mathematical equations where as geo-statistical approaches are based on statistics. In this article four interpolation algorithms were discussed

Inverse Distance Weight, Spline, Kriging and Pointinterp. Manuel Peralvo [6] performed comparative analysis of DEM created after interpolating lines using four techniques including Inverse Distance Weighted, radial basis functions, ordinary Kriging, and TOPOGRID and concluded that deterministic approach are fast in interpolating and are highly application in situations where the data set is large where as geostatistical approaches are flexible but incurs more computation time as it calculates uncertainty in prediction. It was further conclude that TOPOGRID generate quality DEM followed by Kriging and Radial Based Function followed by IDW. Chin-Shung Yang [7] assessed following techniques Inverse Distance to a Power, Kriging , Minimum Curvature, Modified Shepard's, Natural Neighbor, Nearest Neighbor, Polynomial Regression, Moving Average, Radial Basis Function Interpolation, Data Metrics, Local Polynomial, Triangulation with Linear Interpolation from the perspective of applicability, algorithm efficiency and advantage and concluded that applicability of these algorithms depends on the circumstances.

Michael B. Gousie et. al. [8] proposed a way for determining location where intermediate contours can and con not be generated using Hermite splines and then gaps are filled by inverse distance weighting taking into consideration elevation points along cardinal directions. Interpolation of line between existing lines can be done using profile method, proportional distance method and window or TIN method [9]. In case of profile method first a profile is generated through the interpolated point and then spline curve is used. Applicability of profile method is subjected to type of curves in the contour lines. In case of proportional distance, points are interpolated based on distance ratio and in case of window based method a circular window along with the adjacent contours are used to interpolate using polynomial. In case of TIN approach TINs are created using terrain points along contour lines. Mohan Pradhan et. al. [11] implemented a method for interpolating points in order to create intermediate contour. Here the points were generated in between every pair of coordinate points aligned along a particular direction. This work improvises the implemented process [11] by reducing the number of points required for generating interpolated contour lines utilizing the knowledge of spider web construction.

III. METHODOLOGY

The entire work can be explained with the help of the following flow diagram,

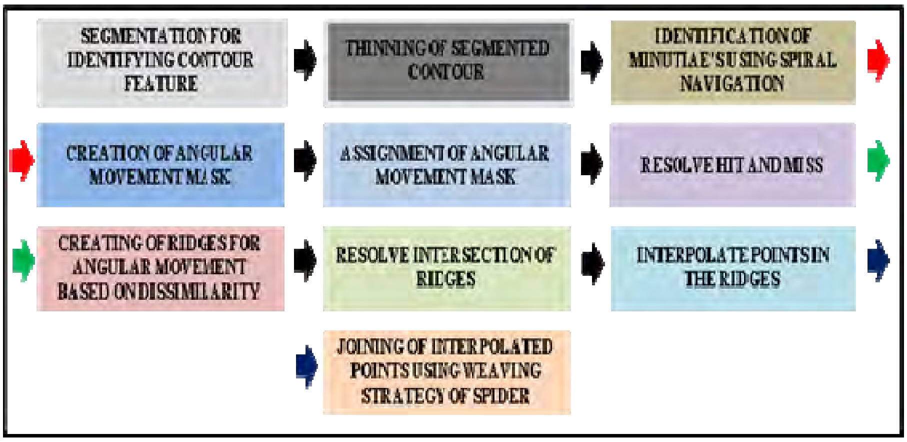


Figure 5: Methodology

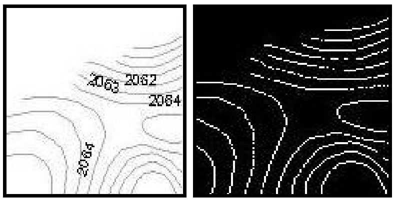
For ease of data manipulation the reference image was converted to gray from RGB format. In RGB format the image is represented as 3D array where in each layer confers to a specific color i.e. the layers represents blue, green and red. So in case of RGB image the resultant coordinate is a result of combination these three colors which further imply that the intensity at a particular point can be made to vary by varying the value at the same coordinate in RGB layers. Whereas gray image has a single layer, where in each value represents shade of gray. While converting RGB image to gray, each coordinate value will be taken as the proportion contribution of value stored at the same index in different layers. So, intensity at a given coordinate x,y in a gray image G is equal to

G(x,y)=proportion contribution of BLUE * Blue(x,y) + proportion contribution of GREEN * Green(x,y) + proportion contribution of RED * Red(x,y)

Whereas the total proportion contribution should be 1.

3.1 Segmentation

Segmentation is the process of identifying only relevant features from a dataset, while ignoring the rest. Segmentation process segments the data set based on the value of the intensity. In this case the intensity values representing contours is taken as basis for segmentation. Segmentation process creates a binary image representing contours using 1 and others using 0



(a) (b)

Figure 6: Sample reference image and segmented image [12]

3.2 Thinning

Thinning or Skeletonization is a morphological operation performed in order to reduce the width of the feature to a single pixel for the ease of data manipulation. This operation thins an object without holes to a line where as an object with hole is reduced to an object with ring whose dimension will be in between the outer boundary and inner boundary.

3.3 Identification of minutiae's using spiral traversal

Minutiae's are elementary represent able component that constitute a morphological feature. In correlation with the segmented contour map minutiae's may be ridges and enclosures. Ridges may complete ridge, ridge ending, ridge enclosure and short ridge. The different ridges are attributed by the way they are organized in the reference map. Ridges or lines are linear feature than runs across the terrain.

In order to detect these minutiae's in the image traditional row column traversal approach may be used. This approach exhausts the dataset by one row at a time while determining the presence of minutiae's. The order of execution in this case is m*n where m is the number of rows and n is the number of columns. On analyzing the orientation of the minutiae's in the image, it is observed that the minutiae's either converges or diverges outwards i.e. the minutia's ending are basically oriented along the peripheral coordinate so instead of row column approach a spiral traversal procedure may be designed that exhausts the dataset in the spiral manner. The advantage of this process is that it is capable of identifying minutiae's ending efficiently in addition the entire dataset may not be traversed to detect the minutiae's so the order of execution may be less than m*n[11].

Spiral traversal can be designed to work either in clockwise direction or in anti clockwise direction, in this implementation clockwise spiral traversal is used. Spiral traversal basically has four integral components in it designed for navigating in four different directions these are travel right, travel down, travel left and then travel up.

- While traveling right the row index is kept static and the column index is incremented by one.
- While traveling down the column index is kept static and the row index is incremented by one.
- While traveling left the row index is kept static and the column index is decremented by one.
- While traveling up the column index is kept static and the row index is decremented by one.

After each spiral is completed the number of rows and columns to be traversed in decrement by one.

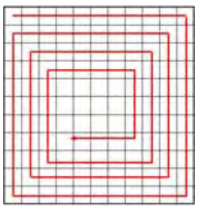


Figure 7: Spiral Traversal Scheme [10]

While traveling spirally through the dataset on encountering a significant value the spiral traversal temporarily stops and minutiae's traversal scheme is initiated. First the minutiae is traversed to determine the extreme end and then the minutia is traversed till the next extreme, while traversing the minutia the coordinate values are stored in the repository. In-order to identify the type of minutia the above state consideration for ridges and enclosures are taken into account.

In addition the spiral traversal scheme efficiently identifies enclosures nested inside another enclosure without any additional complexity.

3.4 Creation of Angular Movement Mask

On analyzing the different orientation patterns of coordinate in the minutiae the following sixteen 3*3 mask have been designed,

TABLE 1: 16 MASKS [11]

1	2	3	4
0 0 0 1 1 1 0 0 0	0 0 0 1 1 0 0 0 1	0 0 1 1 1 0 0 0 0	1 0 0 0 1 1 0 0 0
5	**6**	**7**	**8**
0 0 0 0 1 1 1 0 0	1 0 0 0 1 0 0 0 1	1 0 0 0 1 0 0 1 0	0 1 0 0 1 0 0 1 0
9	**10**	**11**	**12**
0 1 0 0 1 0 1 0 0	0 1 0 0 1 0 0 0 1	0 0 1 0 1 0 0 1 0	0 0 1 0 1 0 1 0 0
13	**14**	**15**	**16**
1 0 0 0 1 0 1 0 0	1 0 1 0 1 0 0 0 0	0 0 1 0 1 0 0 0 1	0 0 0 0 1 0 1 0 1

Each of these sixteen masks represents the possible orientation that a 3*3 subset of minutia centered at a coordinate.

3.5 Assignment of Angular Movement Mask

In-order to assign angular movement mask to the subset of identified minutiae the position of the subset with respect to the Centroid is determined.

Centroid can be determined by using the Centroid formulae.

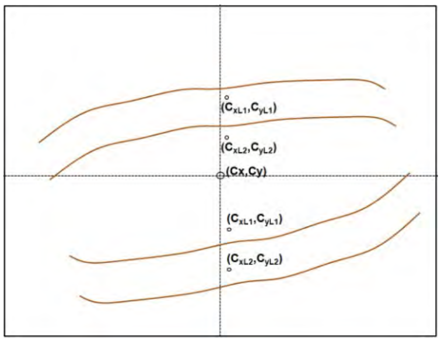


Figure 8: Determination of Centroid [11]

$C_x = (\sum x_i)$/ no of instances where x_i represents x coordinate of significant value.
$C_y = (\sum y_i)$/ no of instances where y_i represents y coordinate of significant value.
where C_x and C_y are the coordinate of the Centroid.

3.5.1 Assignment of direction for lines

In order to assign angular movement mask to the subset of a line the Centroid of the entire line was taken into consideration along with the Centroid of the image.

Irrespective of the position of the Centroid of the line with respect to the Centroid the image the movement will always be done outwards.

- Assignment of angular movement mask, if the Centroid of the image is greater than or equal to the Centroid of the line.

TABLE 2: ASSIGNMENT OF DIRECTION TO THE MASK WHEN $C_x >= C_{xli}$[11]

1	2	3	4
000 111 000	000 110 001	001 110 000	100 011 000
90°	45°	135°	45°
5	6	7	8
000 011 100	100 010 001	100 010 010	010 010 010
135°	45°	45°	0° if y> C_y 180° if y<= C_y
9	10	11	12
010 010 100	010 010 001	001 010 010	001 010 100
135°	45°	135°	135°
13	14	15	16
100 010 100	101 010 000	001 010 001	000 010 101
0°	90°	180°	90°

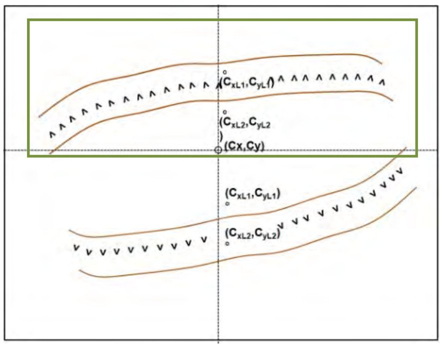


Figure 9: $C_x >= C_{xli}$[11]

- Assignment of angular movement mask, if the Centroid of the image is less than the Centroid of the line.

TABLE 3: ASSIGNMENT OF DIRECTION TO THE MASK WHEN $C_x < C_{xli}$[11]

1	2	3	4
000 111 000	000 110 001	001 110 000	100 011 000
270°	225°	315°	225°
5	6	7	8
000 011 100	100 010 001	100 010 010	010 010 010
315°	225°	225°	0° if y> C_y 180° if y<= C_y
9	10	11	12
010 010 100	010 010 001	001 010 010	001 010 100
315°	225°	315°	315°
13	14	15	16
100 010 100	101 010 000	001 010 001	000 010 101
0°	270°	0°	270°

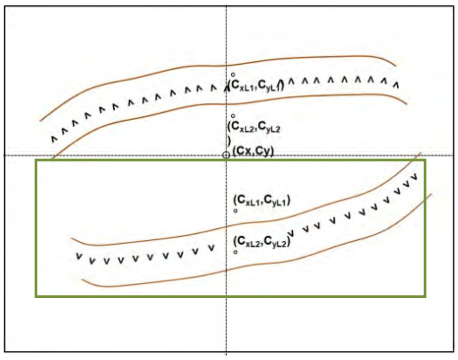


Figure 10: $C_x < C_{xli}$[11]

3.5.2 Assignment of direction for enclosure

In order to assign angular movement mask to the subset of an enclosure the Centroid of the enclosure was taken into consideration along with coordinates points. Irrespective of the position of the coordinate of the enclosure with respect to the Centroid the enclosure the movement will always be done outwards. Inorder to identify the inner most enclosure the repository for the enclosures is sorted in the increasing order of their length and then the enclosures are selected.

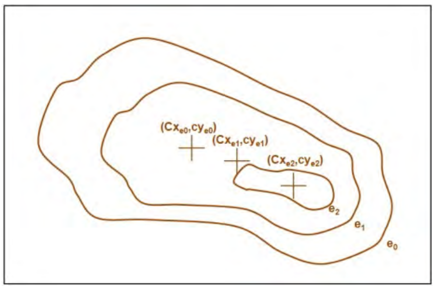


Figure 11: Centroid of the enclosure [11]

- Assignment of angular movement mask, if the Centroid of the enclosure is greater than or equal to the coordinate point

TABLE 4: ASSIGNMENT OF DIRECTION TO THE MASK WHEN C_{XE}>=X[11]

1	2	3	4
0 0 0 1 1 1 0 0 0	0 0 0 1 1 0 0 0 1	0 0 1 1 1 0 0 0 0	1 0 0 0 1 1 0 0 0
90^0	45^0	135^0	45^0
5	6	7	8
0 0 0 0 1 1 1 0 0	1 0 0 0 1 0 0 0 1	1 0 0 0 1 0 0 1 0	0 1 0 0 1 0 0 1 0
135^0	45^0	45^0	0^0 if $y>y_c$ 180^0 if $y<=y_c$
9	10	11	12
0 1 0 0 1 0 1 0 0	0 1 0 0 1 0 0 0 1	0 0 1 0 1 0 0 1 0	0 0 1 0 1 0 1 0 0
135^0	45^0	135^0	135^0
13	14	15	16
1 0 0 0 1 0 1 0 0	1 0 1 0 1 0 0 0 0	0 0 1 0 1 0 0 0 1	0 0 0 0 1 0 1 0 1
180^0	90^0	180^0	90^0

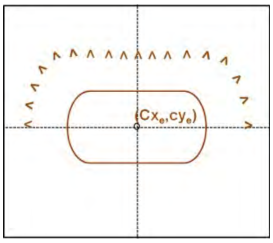
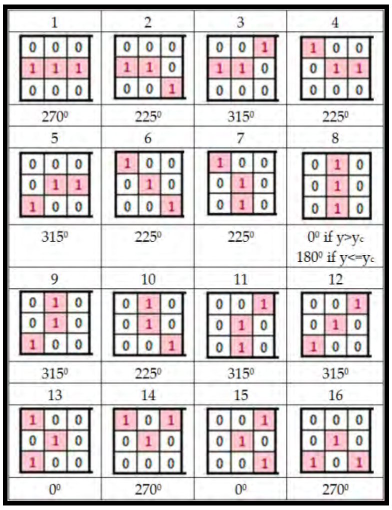


Figure 12: Movement when C_{xe}>=x[11]

- Assignment of angular movement mask, if the Centroid of the enclosure is less than the coordinate point

TABLE 5: ASSIGNMENT OF DIRECTION TO THE MASK WHEN C_{XE}<X[11]



1	2	3	4
0 0 0 1 1 1 0 0 0	0 0 0 1 1 0 0 0 1	0 0 1 1 1 0 0 0 0	1 0 0 0 1 1 0 0 0
270^0	225^0	315^0	225^0
5	6	7	8
0 0 0 0 1 1 1 0 0	1 0 0 0 1 0 0 0 1	1 0 0 0 1 0 0 1 0	0 1 0 0 1 0 0 1 0
315^0	225^0	225^0	0^0 if $y>y_c$ 180^0 if $y<=y_c$
9	10	11	12
0 1 0 0 1 0 1 0 0	0 1 0 0 1 0 0 0 1	0 0 1 0 1 0 0 1 0	0 0 1 0 1 0 1 0 0
315^0	225^0	315^0	315^0
13	14	15	16
1 0 0 0 1 0 1 0 0	1 0 1 0 1 0 0 0 0	0 0 1 0 1 0 0 0 1	0 0 0 0 1 0 1 0 1
0^0	270^0	0^0	270^0

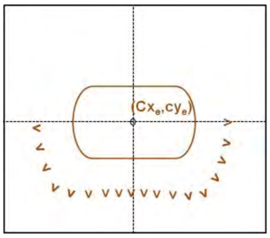


Figure 13: Movement when Cxe<x [11]

3.6 Direction of movement

In case of either type of objects the movement considered is along 0^0, 45^0, 90^0, 135^0, 180^0, 225^0, 270^0 and 315^0 angle between neighboring coordinates is quantized to 45 degrees increments.

TABLE 6: COORDINATE MANIPULATION FOR MOVEMENT

Angle	Row	Column
0^0		increment
45^0	decrement	increment
90^0	decrement	
135^0	decrement	decrement
180^0		decrement
225^0	increment	decrement
270^0	increment	
315^0	increment	increment

The increment or decrement is done until a significant value is encounter or the boundary coordinate is reached.

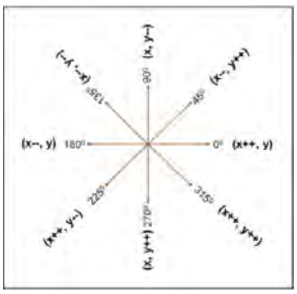
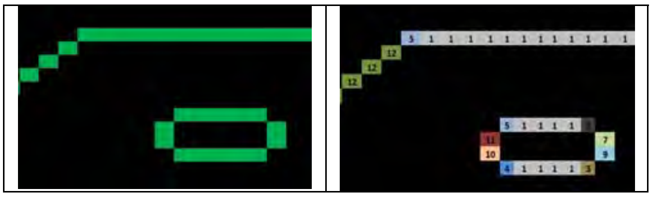


Figure 14: Operation along directions

TABLE 7: ASSIGNMENT OF DIRECTION [11]

Sample Segment	Assignment of Mask



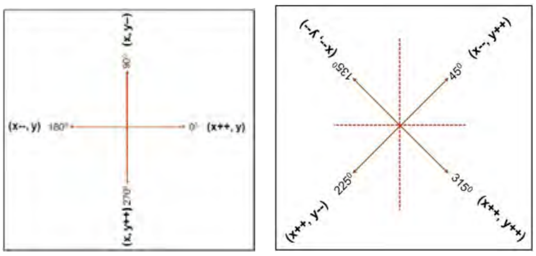
3.7 The problem of Hit and Miss

While making angular movement based on the direction assigned either in the case of line or an enclosure, in certain case the chances of hitting and missing the significant values are equally likely. In case if the angular movement hits a significant value than the thread will be correctly placed but in case of a miss the thread will be wrongly placed or not placed at all. Considering the angular movement 0^0, 45^0, 90^0, 135^0, 180^0, 225^0, 270^0 and 315^0 the chance of hit and miss are as

TABLE 8: PROBABILITY OF HIT AND MISS ALONG THE ANGULAR DIRECTIONS

Angle	Hit	Miss
0^0	Yes	No
45^0	Yes	Yes
90^0	Yes	No
135^0	Yes	Yes
180^0	Yes	No
225^0	Yes	Yes
270^0	Yes	No
315^0	Yes	Yes

So it can be conclude that along angular movement 45^0, 135^0, $225^0$and 315^0 the chance of hit and miss are equally likely.



(a) (b)

Figure 15: (a) no chances of miss (b) chance of hit and miss equally likely [11]

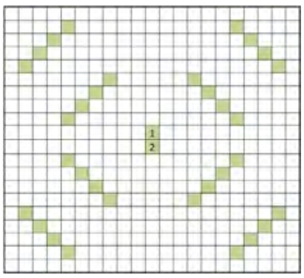


Figure 16: Sample Example [11]

Let us consider that 1 and 2 are the points from where the thread is to be created then angular movement from one and two in any of the direction highlighted in Figure 15 (b) results in

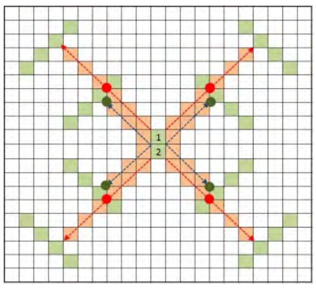


Figure 17: Hit and Miss [11]

Where red dots represent miss and the green dots represents hit, so on moving either from 1 or 2 results in either in hit or miss. Further for interpolating points for creating intermediate contour line these threads are divided at intervals.

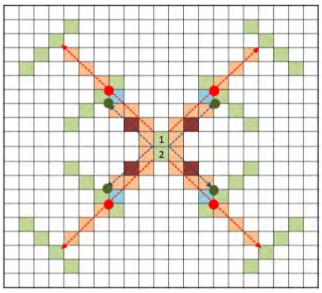
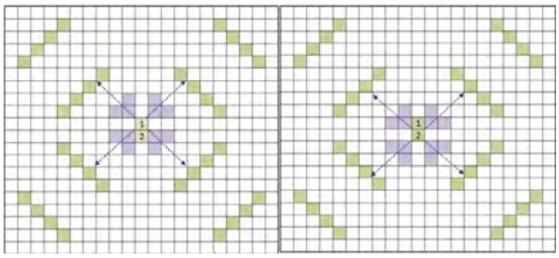


Figure 18: Wrongly placed interpolated points due to miss [11]

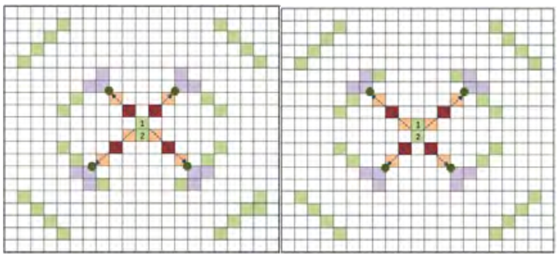
Brown points are the correctly placed interpolated points due to hit and blue points are wrongly placed interpolated points due to miss. So, in order to resolve this issue an advanced mask was designed for angular movement highlighted in Figure 15(b).



(a) (b)

Figure 19: Design of mask for angular movement highlighted in Figure 15(b) [11]

On movement along the angular direction highlighted in Figure 19 (a&b) using the advanced mask the probability of miss is reduced to 0. [11]



(a) (b)

Figure 20: Design of mask for angular movement highlighted in Figure 15(b)

3.8 Creating of thread for angular movement based on dissimilarity of angular movement

Upon resolving hit and miss associated with the angular movements highlighted in Figure 19(b) threads are to be created from the coordinates along the direction assigned.

Threads can be created from all the coordinated pertaining to minutiae, but this process will require greater computation time. As represented in Figure 21.

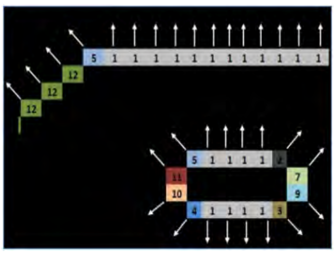


Figure 21: Direction for creating threads taking into consideration each and every coordinate in the minutiae.

Instead of creating threads from all coordinate threads can be created whenever there is change in the direction of traversal. So if the threads are drawn only when there is transition in directional movement then the result for the same would be as represented in Figure 22. This would considerably reduce the amount of computation required and time.

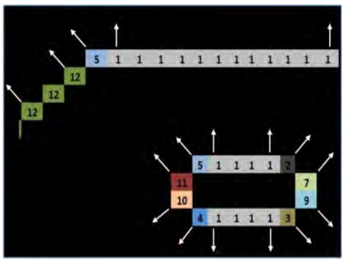
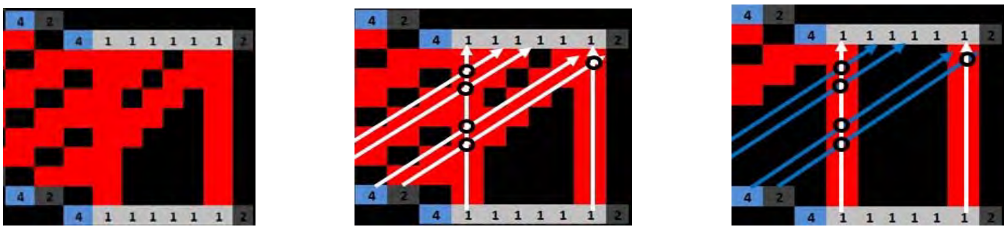


Figure 22: Direction for creating threads taking into consideration change in direction

3.9 Resolve intersection of ridges or threads

While creating threads along the direction identified in the step above, the threads may intersect with each other. So, in order to prevent this while creating thread if there exist a significant value pertaining to another thread along the path then the current thread is ignored.



(a) (b) (c)

Figure 23: (a) Image with overlapping threads (b) Determination of intersection (c) resolution of overlapping threads

3.10 Interpolate points in the ridge or the thread

After resolving overlapping threads, points are to be interpolated along the threads which further needs to be reconnected in order to create intermediate contour. The interpolated points are to be stored in sequence with the threads pertaining to the minutiae for correct reconnection.

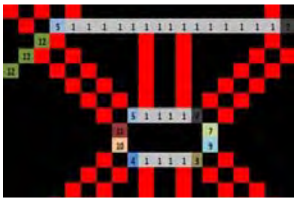


Figure 24: Threads to be interpolated

3.11 Reconnection of interpolated points using weaving strategy of spider

In order to connect interpolated points Bresenham's line drawing algorithm is used, the interpolated points are connected in sequence in the way how spider weaves the nest.

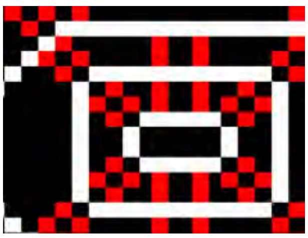


Figure 25: connected interpolated points.

IV. RESULTS AND DISCUSSION

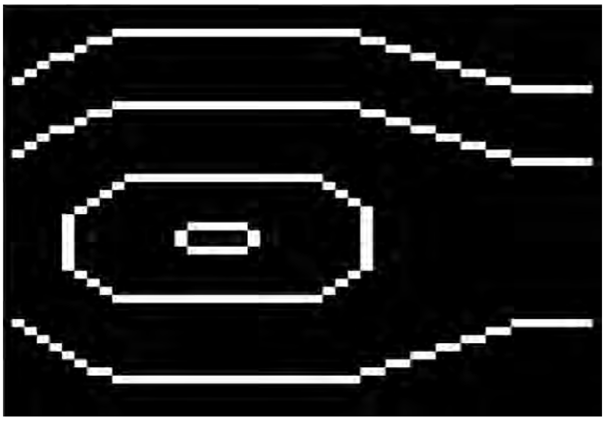


Figure 26 (a): represents the sample dataset where intermediate contour lines are to be interpolated.

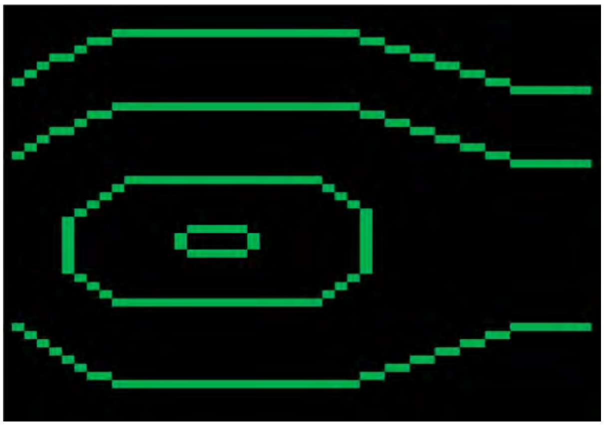


Figure 26 (b) : represents the various minutiae's identified by the spiral traversal process

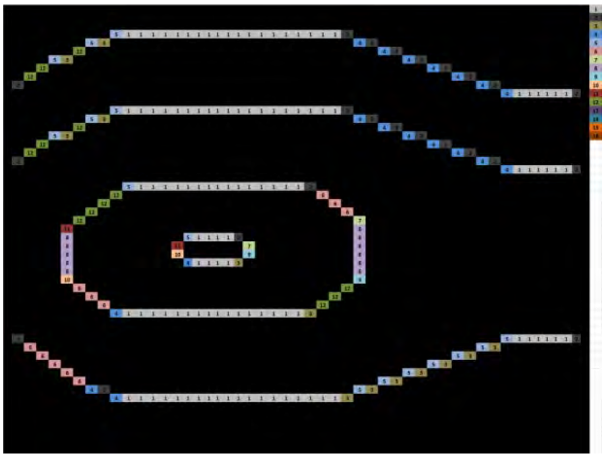


Figure 26 (c): represents the assignment of mask for determining movement as per table 2-5.

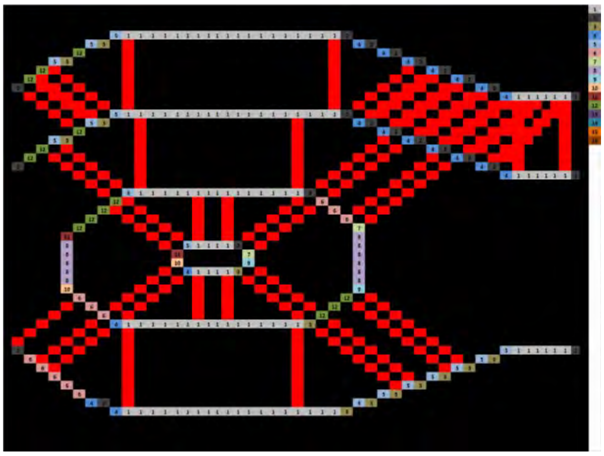


Figure 26 (d): represents the threads created along the coordinates of a minutiae based on change in direction or dissimilarity

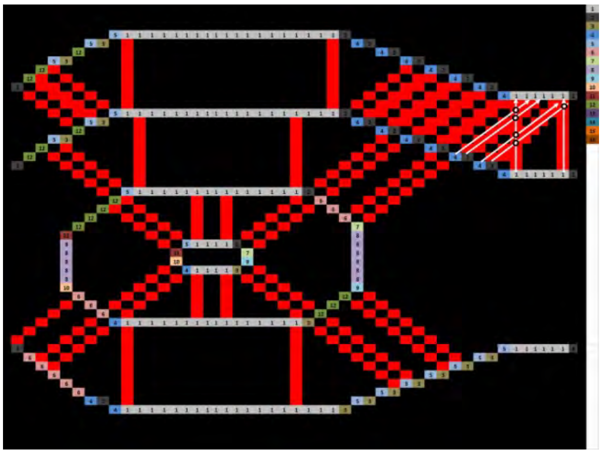


Figure 26 (e): represents identification of intersection along the created threads.

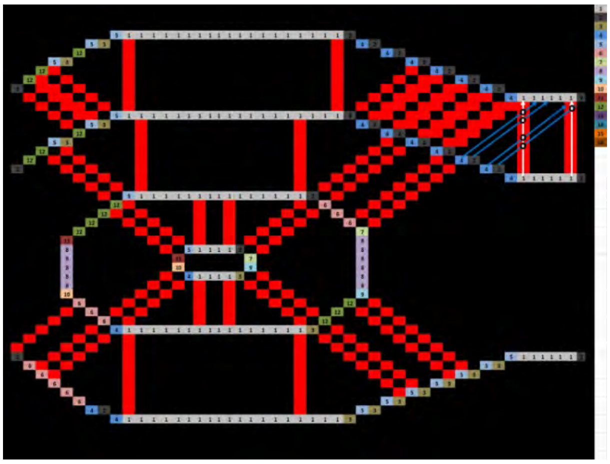


Figure 26 (f): represents removal threads that intersects with other threads.

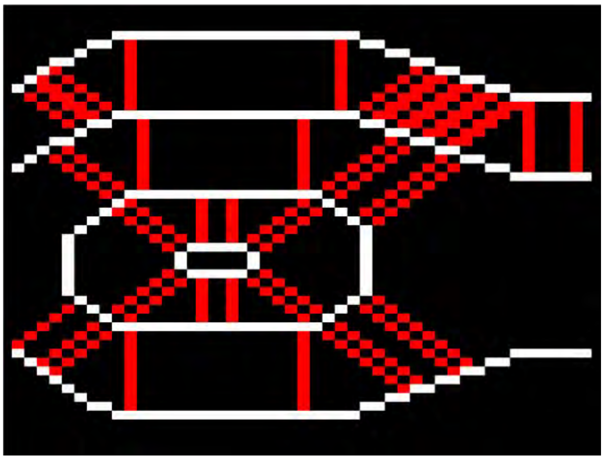


Figure 26 (g): represents combining threads with the sample data set.

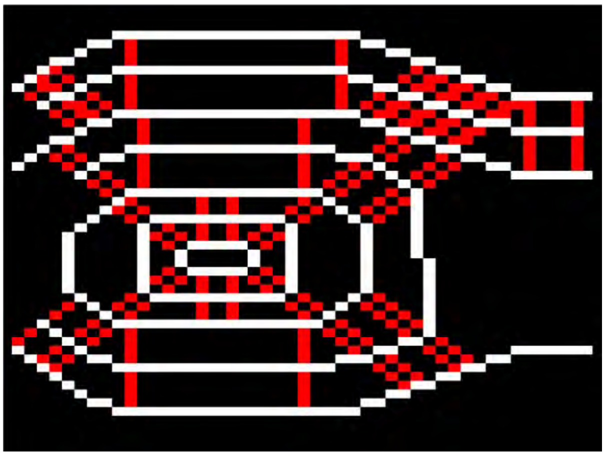


Figure 26 (h): represents creation of interpolated line obtained after connecting interpolated points in each of the thread.

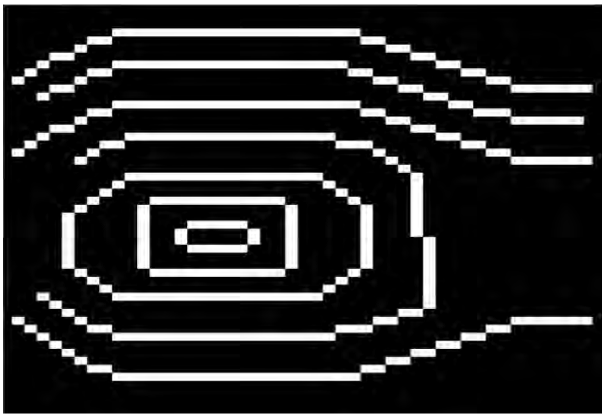


Figure 26 (i): represents the sample dataset along with the interpolated lines

V. CONCLUSION

The implemented work acquires knowledge from the weaving strategy deployed by a spider to create a web. It also highlights the possible orientation of subset pertaining to the minutiae and assigns angular traversal direction based on their position relative to certain reference point. It improvises the process by first reducing the number of threads required for creating a stable structure by ignoring continuous coordinate that has same angular traversal direction and considering only the angular transition. It also removes threads that are intersecting with other threads in order to prevent improper interpolation followed by division of these threads to identify the reconnection points. The identified reconnection points were later connected using the knowledge used by the spider to weave radial spiral threads.

The implementation efficiently interpolates intermediate contours between enclosures or ridges or between enclosures and ridges.

REFERENCES

[1] Christopher Gold, Maciej Dakowicz "Improving Accuracy by Incorporating Skeleton Points and Slope Information Digital Elevation Models from Contour Lines" GIM International 2003, pp56-59

[2] Qing Wang and Rabab Ward, "A Contour-Preserving Image Interpolation Method", ICIP 2003, pp 773-676

[3] Jianyun Chai, Takaharu Miyoshi, Eihachiro Nakamae "Contour Interpolation and Surface Reconstruction of Smooth Terrain Models", IEEE Visualization 1998: Research Triangle Park, North Caroline, USA, pp 27-33

[4] Michael B Gousie, "Converting Elevation Contours to a Grid", Dept. of Geography, Simon Fraser University, 1998, pp 647-656

[5] Colin Childs, Interpolating Surfaces in ArcGIS Spatial Analyst, ArcUser July-September 2004, pp 32-35

[6] Manuel Peralvo, Influence of DEM interpolation methods in Drainage Analysis

[7] Chin-Shung Yang, Szu-Pyng Kao, Fen-Bin Lee, Pen-Shan Hung, "Twelve Different Interpolation Methods: A Case Study of SURFER 8.0" XXth ISPRS Congress Technical Commission II July 12-23, 2004 Istanbul, Turkey, pp- 778-785 .

[8] Michael B. Gousie Wm. Randolph Franklin, "Constructing a DEM from Gridbased Data by Computing Intermediate Contours" Proceedings of the Eleventh ACM International Symposium on Advances in Geographic Information Systems, November 7–8, 2003, New Orleans, Louisiana, USA, pp 71-77

[9] http://stlab.iis.u-tokyo.ac.jp/~wataru/lecture/rsgis/giswb/ vol2/cp3 /cp3-4. htm(Link).

[10] Mohan P. Pradhan, M.K. Ghose, "Automatic Association of Stream Order for Vector Hydrograph Using Spiral Traversal Technique", IOSR Journal of Computer Enginering, Volume 1, Issue 5, pp 09-12, 2012.

[11] Mohan P. Pradhan, M.K. Ghose "Line Generation between Existing Contours In Order to Reduce Stair Case Effect" International Journal of Scientific & Engineering Research, Volume 4, Issue 6, June-2013, pp 2873-2881, 2013

[12] Mohan P Pradhan, M K Ghose, Pooja S Rai, Nilanjan Mukherjee, Knowledge based Contour Line Reconnection Techniques, International Journal of Computer Applications (0975 – 8887), Volume 65– No.9, March 2013, pp 37-42

[13] Early stages of orb web construction in Araneus diadematus Clerck — Zschokke S — Revue Suisse de Zoologie hors série 2: 709-720

AUTHORS PROFILE

Mohan P Pradhan, He received B. Tech, M. Tech degrees in 2006 and 2009 respectively from Sikkim Manipal University, Sikkim, India. He is currently persuing his Ph. D for Sikkim Manipal University in the field of automatic digitization for GIS applications. He is currently working as Assistant Professor in department of Computer Science and Engineering, Sikkim Manipal Institute of Technology, Sikkim Manipal University since August 2006. His research interest includes RS and GIS, Algorithms, Image Processing and Software Engineering.

Professor (Dr.) M. K. Ghose is the Dean (R & D), SMIT and Professor & Head of the Department of Computer Science & Engineering at Sikkim Manipal Institute of Technology, Mazitar, Sikkim, India since June, 2006. Prior to this, Dr. Ghose worked in the internationally reputed R & D organization ISRO – during 1981 to 1994 at Vikram Sarabhai Space Centre, ISRO, Trivandrum in the areas of Mission Simulation and Quality & Reliability Analysis of ISRO Launch vehicles and Satellite systems and during 1995 to 2006 at Regional Remote Sensing Service Centre, ISRO, IIT Campus, Kharagpur in the areas of RS & GIS techniques for the natural resources management. He was also associated with Regional Engg. College (NIT), Silchar (1979 – 1981) as Teaching Asst. and Assam Central University, Silchar as COE and HOD of Computer Science Department (1997-2000). His areas of research interest are Data Mining, Simulation & Modelling, Network, Sensor Network, Information Security, Optimization & Genetic Algorithm, Digital Image processing, Remote Sensing & GIS and Software Engineering.