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Computers & Geosciences 30 (2004) 45–57

COMPUTERS & GEOSCIENCES

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Comprehensive Strip Based Lineament Detection Method (COSBALID) from point-like features: a GIS approach

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Received 16 September 2002; received in revised form 19 September 2003; accepted 30 September 2003

Abstract

Comprehensive Strip Based Lineament Detection (COSBALID) is a new method that detects lineaments from point-like features. It is based on the strip concept and composed of various steps, which apply filtering techniques in order to increase the accuracy and linearity of detected lineaments. The structure of the method is so robust that its parameters and variables are partially data driven giving the user great flexibility to adopt and modify them dynamically, in the course of processing, and impose new parameters at any step without altering the main structure of the method. The main steps of the method are as follows: (1) creation of a database using a GIS medium, (2) configuration of strips (polygons) (3) creation of an initial (strip) database by rotating the strips incrementally, (4) detection of unrefined alignments, (5) distance filtering, (6) linearity check, (7) repetition and redundancy check, and (8) further analysis based on various properties of the point like features.

The method is applied to 94 volcanic cones within the Cappadocian Volcanic Province. The initial number of alignments is 2485 which gradually decreases to 25 after performing above-mentioned test and filters.

The advantage of COSBALID method, over existing models is that it detects the exact geographical position of the end members of the lineaments. In addition, the method considers additional properties of point-like features such as type and shape.

Keywords: COSBALID; Lineament detection; Point-like feature; GIS; Cappadocia; Turkey

1. Introduction

Lineaments are relatively large linear features derived from remotely sensed data, air photos, geophysical, and geological maps (O'Leary et al., 1976). The term "geological lineament" is used to refer to linear features detected on aerial photographs and satellite images, which presumably have a geological origin (Campbell, 1996). Davis (1984) stated that the long, straight to curved lineaments defined by aligned topographic features serve to mark the locations of fault traces. Depending on their size, depth and the terrain, however, geological structures can be recognized in the field as well as from aerial photographs, topographic maps, airborne geophysical surveys and even satellite images, although ground-checking is required to confirm the interpretation that a specific lineament is indeed the trace of a fault (Davis, 1984).

Another way of detecting lineaments is to identify alignments within randomly distributed point-like features. Geological examples of such points are igneous complexes, ore bodies, earthquake epicenters, sag ponds, springs, karstic features, etc. Location and spatial distribution of such points are believed to be influenced by the geological structures in the crust. Ideally, one would establish a one-to-one correlation

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0098-3004/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/j.cageo.2003.09.004

between the locations of lineaments and point-like features associated with them. In practice, this has rarely been achieved (Lutz, 1986).

Several statistical procedures and methodologies have been developed to detect alignments from the spatial distribution of point-like features. For example, Lutz (1986) developed the two-point azimuth (TPA) method that quantifies azimuths of lines connecting all pairs of points within an area of interest (e.g. Wadge and Cross (1988) applied the TPA to the vents of Michoacan-Guanajuato volcanic field in Mexico). The first step of this method requires the connection of all points to each other and then the construction of frequency diagrams from the azimuths of the connection lines. This means that $\boldsymbol{n}(\boldsymbol{n}-\mathbf{1})/\mathbf{2}$ line azimuths will be counted where "$\boldsymbol{n}$" denotes the number of data points. The frequencies are interpreted in the final step. One of the drawbacks is that it is very dependent on the shape of the working area, which imposes a bias over the directions detected and the method always produces a result, even if there is no alignment. In order to remove the bias forced by the geometry of the working area, the Monte Carlo simulation is applied by Lutz (1986). However, the method still cannot determine the positions of the lineaments.

Another procedure is Hough transform (HT) method, which has been used to detect alignments from volcanic vent distributions. Wadge and Cross (1988), Connor (1990) and Connor et al. (1992) used the HT method to determine the alignment directions as well as their geographical positions. Wadge and Cross (1988) concluded that the method simulates human visual capability, whereas, human visual interpretation is poor at selecting sets of widely spaced points on which HT method depends.

Zhang and Lutz (1989) invented a new statistical method to analyze the structurally controlled point-like features. They applied their method to igneous complexes and kimberlites. The method is used to estimate the geographical positions as well as the trends of the features that could control magmatic activity. They defined a region for a given set of points using a complex bounding polygon and dividing it into parallel strips. They vary the orientation and length of the strips continuously while keeping the track of the density in each strip. Accordingly, the locations of strips with anomalously high densities could indicate zones of structural control, which need further analyses.

Lutz and Gutmann (1995) proposed a modified version of the TPA method of Lutz (1986) that uses a concept called kernel density, which overcomes the problems created by the selection of grid size. The estimation of kernel density permits treatment of heterogeneous distributions without introducing a substantial dependence on the choice of the grid employed in the test for significance of apparent preferred orientations. The method can selectively reveal alignments on different spatial scales and can suggest the geographical locations of alignments as well as their orientation.

There are two major drawbacks to all of the above-mentioned methods. These are:

(1) The exact geographical positions of the end-members of the detected alignments are not well identified. In most cases, the final evaluation is made on frequency (histograms or rose) diagrams, and/or density diagrams which display only the trends of the lineaments.
(2) The features in the data set are just treated as "points with **x** and **y** coordinates" and other attributes are ignored. These features, however, may comprise valuable extra information in addition to their coordinates. Some examples of such attributes are size, shape, elongation, age, lithology, etc.

The purpose of this study is to present a new method based on the strip concept (Zhang and Lutz, 1989) to detect alignments from the point-like features using their spatial, geometrical, and/or geological characteristics. The method is named Comprehensive Strip Based Lineaments Detection (COSBALID). Such an approach first requires a spatial database, which necessitates the use of geographical information systems (GIS) technology and can be applied to any kind of point-like features.

2. Algorithm of the COSBALID method

The method is composed of 9 successive steps starting from initial data setup and ending with the final product (Fig. 1). There are various intermediary products, which may provide database for the succeeding steps, produced during its execution. Fig. 2 portrays the structure and first few records of these intermediary products. The forthcoming section describes major characteristics of the steps and the application of this method to the volcanic cones of the Cappadocian Volcanic Province (Turkey).

2.1. Step 1—creation of initial database

The first step is to create a database that contains coordinates of the point-like features and related additional information in a GIS medium. Additional attribute information is of vital importance during the assessment of the detected alignments particularly in the latest steps. The structure of database depends on the nature of the data set. For example, volcanic

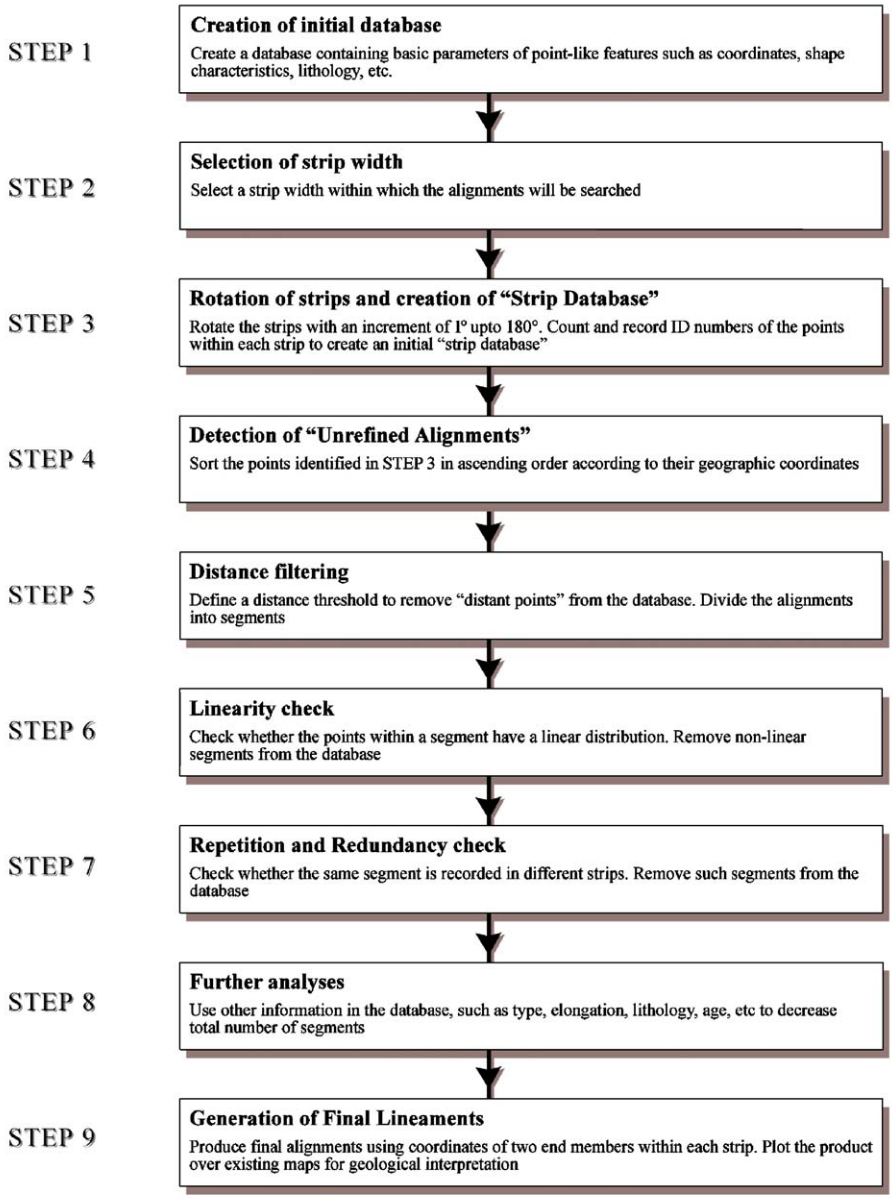

Fig. 1. Flowchart of COSBALID method.

cones, earthquake epicenters or karstic features require different database configurations. The database for volcanic eruption centers (volcanic cones) used in this study contains the following attributes: Point ID No, type of cone, geographical coordinates, long and short axes of elliptical cones, height of cone, azimuth of long axis, lithology, volume and age (Fig. 2A). Other parameters such as distance to the nearest cone, degree of elongation etc., can be generated and added to the database using existing information.

2.2. Step 2—selection of strip width

The backbone of this method is the division of the working area into parallel strips of finite width. The strips constrain the contained points to be aligned parallel or sub-parallel to a given direction. Although the strip width can change from one area to another the width of the strips should be uniform while applying the method to a certain area. The optimum strip width can be achieved by considering the parameters such as, point

A. Initial database (Step 1)

Id no	Type	Easting (m)	Northing (m)	Long axis (m)	Short axis (m)	Height (m)	Azimuth (degree)	Lithology	Volume (Million m3)	Age (Ma)
1	Cone	458582	4475784	480	450	330	110	Basalt	18.28	0.15
2	Dome	442128	4500147	625	575	450	068	Rhyolite	42.41	0.27
3	Cone	438432	4489850	540	230	250	123	Basalt	29.38	0.24
.	.	.	.	.	.	.	.	.	.	.

B. Strip database (Step 3)

Angle (1° to 180°)	Strip no (1 to n)	Number of points	Point IDs (in database order)
1	6	7	11, 22, 25, 46, 65, 84, 126
1	11	8	16, 32, 51, 52, 55, 84, 112, 174
2	5	7	11, 13, 16, 22, 38, 76, 84
2	6	3	12, 23, 41
3	21	9	9, 12, 14, 26, 31, 77, 98, 136, 178
3	17	5	5, 7, 19, 64, 75
.	.	.	.

C. Database of unrefined alignments (Step 4)

Angle (1° to 180°)	Strip no (1 to n)	Number of points	Geographically sorted point IDs
1	6	7	46, 126, 25, 65, 84, 11, 22
1	11	8	55, 32, 16, 52, 174, 112, 84, 51
2	5	7	16, 76, 38, 13, 84, 11, 22
2	6	3	23, 41, 12
3	21	9	31, 98, 14, 136, 77, 9, 178, 12, 26
3	17	5	64, 7, 19, 75, 5
.	.	.	.

D. Segment database created after distance filtering (Step 5)

Angle (1° to 180°)	Strip no (1 to n)	Segment no	Number of points	Point IDs
1	6	1	4	46, 126, 25, 65
1	6	2	3	84, 11, 22
1	11	1	3	55, 32, 16
1	11	2	3	174, 112, 51
2	5	1	4	16, 76, 38, 13
2	5	2	3	84, 11, 22
3	21	1	5	31, 98, 14, 136, 77
3	21	2	4	9, 178, 12, 26
3	17	1	4	64, 7, 19, 75
.	.	.	.	.

E. Database after linearity check (Step 6)

Angle (1° to 180°)	Strip no (1 to n)	Segment no	Number of points	Point IDs
1	6	2	3	84, 11, 22
1	11	2	3	55, 32, 16
2	5	1	4	16, 76, 38, 13
2	5	2	3	84, 11, 22
3	21	1	5	31, 98, 14, 136, 77
.	.	.	.	.

F. Database after repetition and redundancy check (Step 7)

Angle (1° to 180°)	Strip No (1 to n)	Segment no	Number of points	Point IDs
1	6	2	3	84, 11, 22
1	11	2	3	55, 32, 16
2	5	1	4	16, 76, 38, 13
3	21	1	5	31, 98, 14, 136, 77
.	.	.	.	.

G. Final lineament database (Step 9)

Lineament no	Easting (1)	Northing (1)	Easting (2)	Northing (2)	Additional needed information
1	453699	4505444	459003	4513615	. . . .
2	385596	4484244	391539	4491585	. . . .
3	460506	4505753	469948	4505637	. . . .
4	461115	4480541	463482	4489617	. . . .
.	.	.	.	.	

Fig. 2. (A–G) Database structure of COSBALID method.

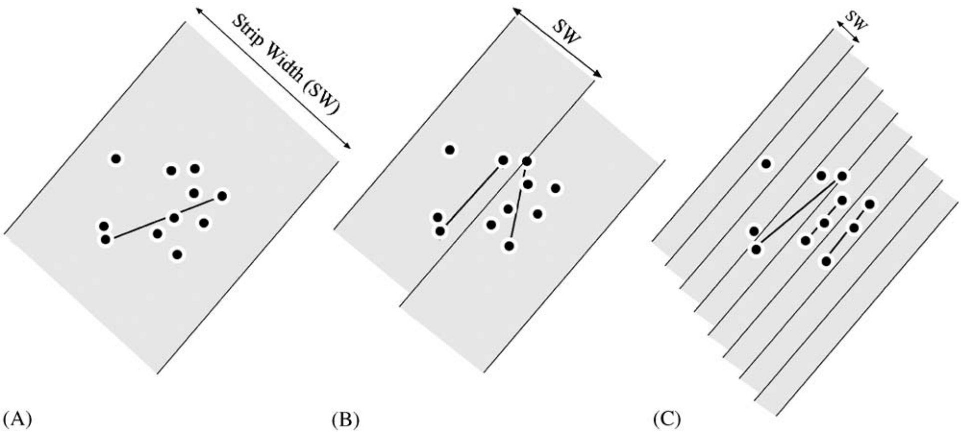

Fig. 3. Effect of strip width in detection of alignments. Circles represent point-like features. Solid lines are alignments within each strip that connects farthest points. Note that number of discarded points increases in large strip width (A). As strip width decreases number of discarded points decreases and detected alignments increase (B–C).

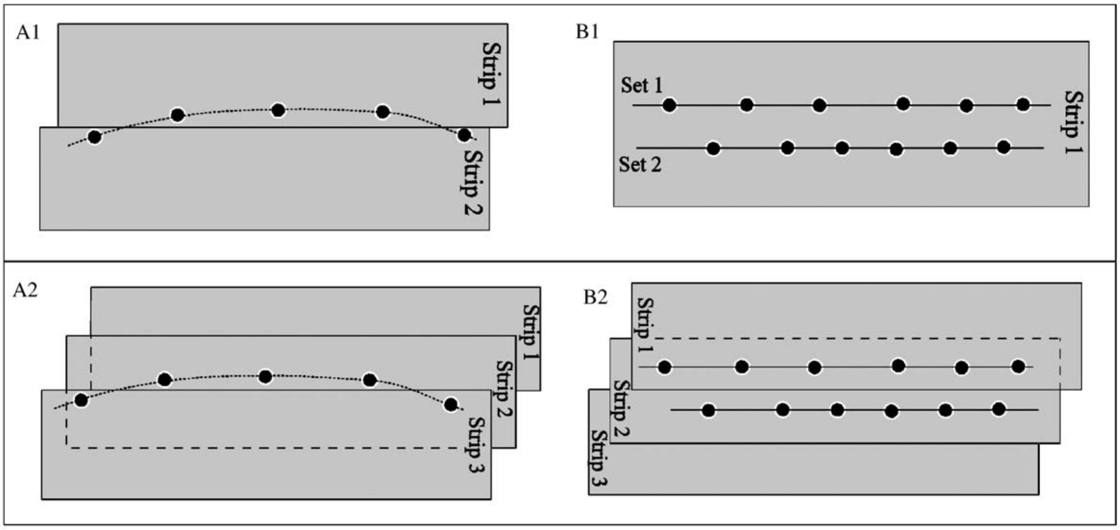

Fig. 4. Negative effect of strip width and position of strips on detection of alignments. Narrow width misses curvilinear lineaments (A1); large strip width misses two aligned sets (B1). Solution to these problems by strip overlap (A2 and B2).

density, spacing, size of the area, nature of the data, etc. Obviously, as the width of the strips increases the number of points within each strip increases while the number of alignments to be detected decreases (Fig. 3).

The negative effect of strip width is illustrated in Fig. 4 for two special cases. In the first case a curvilinear lineament is missed due to narrow width (A1). In the second case two perfectly aligned sets of points are missed due to large strip width (B1). In both cases the main cause of the problem is geographic position of the strips. That means the alignments can be detected if the strips are properly positioned. This problem, therefore, can be solved by modification of the initial strip configuration which considers strip overlap (Fig. 4A2 and B2). The same alignments might be detected in the two overlapping strips, but will be eliminated during either linearity or repetition check in the later stage of the method.

2.3. Step 3—strip rotation and creation of "strip database"

The strips are rotated with a certain incremental angle, e.g. 1° of increment up to 180° starting from 1° (Fig. 5). By doing this, the possible alignments in any direction will be detected. For example, if the area is

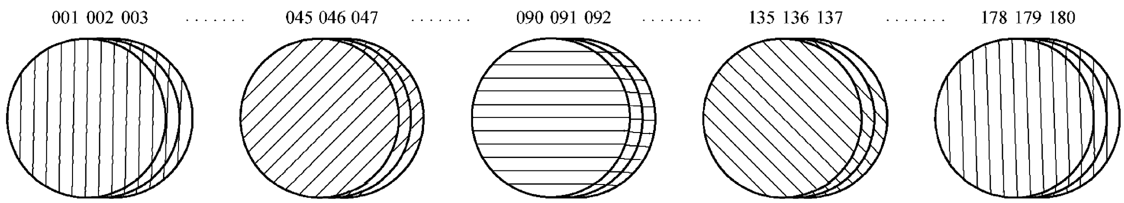

Fig. 5. Rotation of strips in COSBALID method.

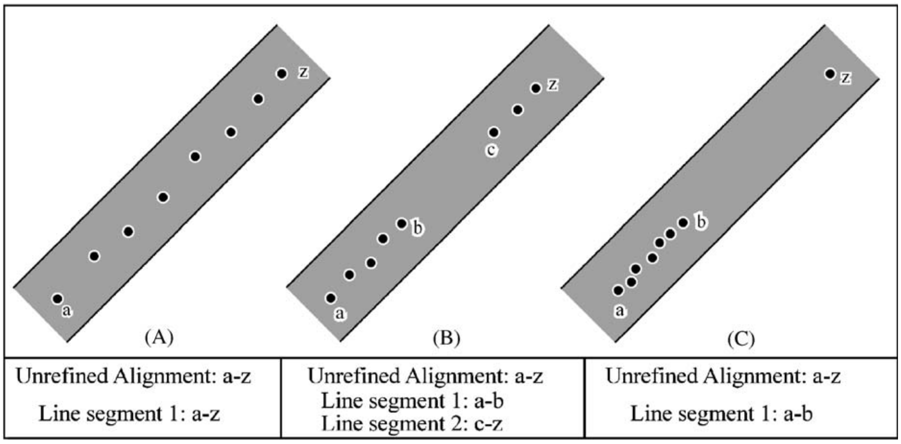

Fig. 6. (A–C) Point distribution and segmentation of an unrefined alignment.

divided into 100 strips, the subroutines in the GIS software will incrementally rotate the strips and record the points within each strip. The number of points and their parameters for 18,000 ($180^\circ \times 100$) strips are collected and stored as a "*Strip Database*". This database includes Point IDs', spatial and attribute information. This database has four columns including the angle of rotation, the strip number, the point frequency, and a list of point IDs (Fig. 2B).

2.4. Step 4–detection of unrefined alignments

In this step, the points for each strip and for each orientation are sorted geographically. The coordinates of the two most distant points (i.e. end members) within a strip are connected to produce "unrefined alignments" (Fig. 2C). This step, therefore, will produce an output similar to the output of TPA method of Lutz (1986). An initial filter, based on the frequency of points, can be used here to discard certain alignments. In the database shown in Fig. 2C, for example, the alignments containing two points are not included.

2.5. Step 5—distance filtering/segmentation

An unrefined alignment in a strip detected in Step 4 may not be geologically meaningful since this line is simply defined by the distance between two end members in the strip. However, the distance between each pairs of the points should be "reasonable" in order to consider this line as an alignment. Therefore, a distance threshold filter should be applied. This filter, on one hand, investigates whether the points have a reasonable distance. On the other hand, it searches for the possibility of segmentation of an alignment.

Three cases of segmentation are illustrated in Fig. 6. In the first case (A), all the points are, more or less, equally spaced implying that there is no segmentation. In this case, there will be one alignment between points "*a*" and "*z*" if the distance between the points is reasonable. In the second case (B), the raw alignment is composed of two segments with a separation greater than the distance threshold. Therefore, this strip possesses two segments between "*a*" and "*b*", and between "*c*" and "*z*". In the last example (C), the alignment is between "*a*" and "*b*", where the last point is discarded due to the distance threshold.

During the process, the distance to the closest point will be calculated starting from the first point in the strip (Fig. 7). If it is less than the distance filter, these two points will be recorded and the next distance between second and third points will be calculated. This procedure will be repeated until two points with a distance greater than the filter size is encountered. In this case, the last point fulfilling the distance filter will be marked as the end point. The line connecting the first and the end point is recorded as the first segment in the strip. After marking the first segment, the process of filtering continues to check the possibility of other segments within the same strip starting from the successive point after the first segment. The procedure is repeatedly applied until the last point in the strip is processed. The database created after the distance filter process has been completed is stored as a new database and contains the segments in each strip (Fig. 2D). In the sample database three alignments are found to be composed of two segments.

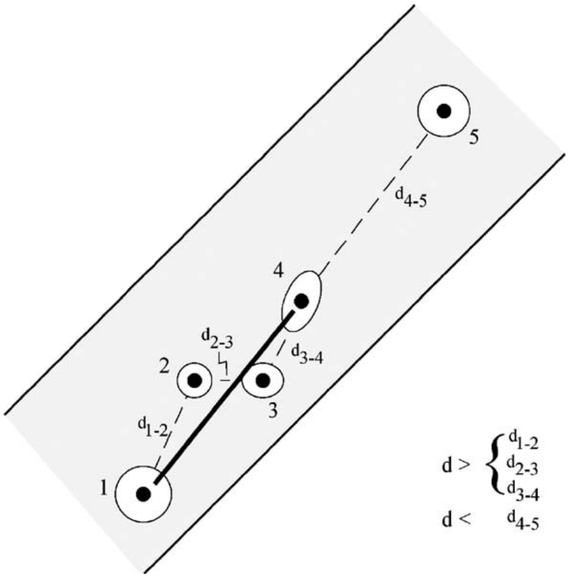

Fig. 7. Application of distance filter (d) within a strip. Note that point 5 is discarded since distance is greater than d.

The density (concentration) of the points in the area is the main factor in determining the selection of the distance filter. A large filter size in densely populated areas will increase the number of points and the length of the segments within a strip. In contrast, the same filter size within a less dense area may detect fewer lineaments relative to the denser one. In addition, in densely populated areas using a small filter size may result in a number of short segments within the same strip by breaking down the long segments into pieces.

The size and the shape (e.g. diameter) of the point-like features are also important parameters that should be considered in the distance filter selection. If the size of the features is uniform, a unique distance filter may be selected. On the other hand, if the object size is variable, then a constant distance filter may not work properly. The distance between larger objects will be larger than that of the objects with smaller size as illustrated in Fig. 8. In the case of elliptical objects, long and short axes can be used to determine the distance filter (Fig. 9). The distance between the features (feature proximity) and their average size may help the user to determine the filter length. Otherwise, an expert knowledge, based on various characteristics of the region or other statistical approaches may be applied (e.g. *kernel density* approach of Lutz and Gutmann, 1995).

2.6. Step 6—linearity check

The purpose of this step is to examine whether the points within each segment are aligned over a straight line or are irregularly distributed. A linearity ratio is assigned to each segment which is calculated by the division of the distance between two end members in a segment to the total path traveled through all points

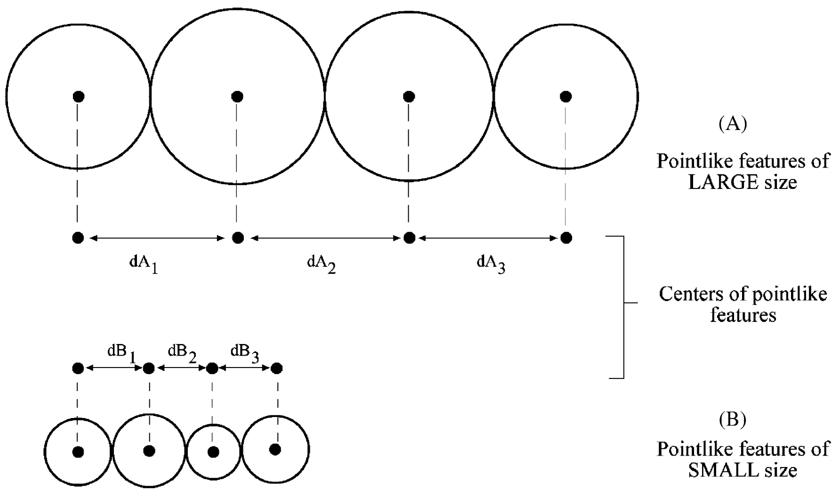

Fig. 8. (A, B) Consideration of object size to determine distance filter. Note that distance between centers of points in Group A is larger than Group B due to their size.

within the same segment (Fig. 10). The ratio of these two lines (linearity ratio-R_L = segment length/cumulative length) is a measure of the deviation from the main direction of the alignment. Those segments with ratios less than a reasonable linearity ratio (e.g., case C in Fig. 10) are discarded from the database. This ratio can be determined by the user and/or statistical methods.

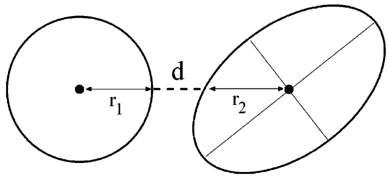

Fig. 9. Illustration of distance filters for two objects having different shapes. Length of the filter is equal to distance between two margins (*d*) instead of distance between two centers.

2.7. Step 7—repetition and redundancy check

The present database should be examined and verified repeated and/or are redundant segments in the adjacent strips. Repetition refers to the segments detected in several strips that contain the same set of points (Fig. 11A). This will result in the recording of the same segments in several strips at nearby angles. In order to identify such segments, the database can be sorted according to the end members of the segments. The azimuth of each segment is correlated with the strip

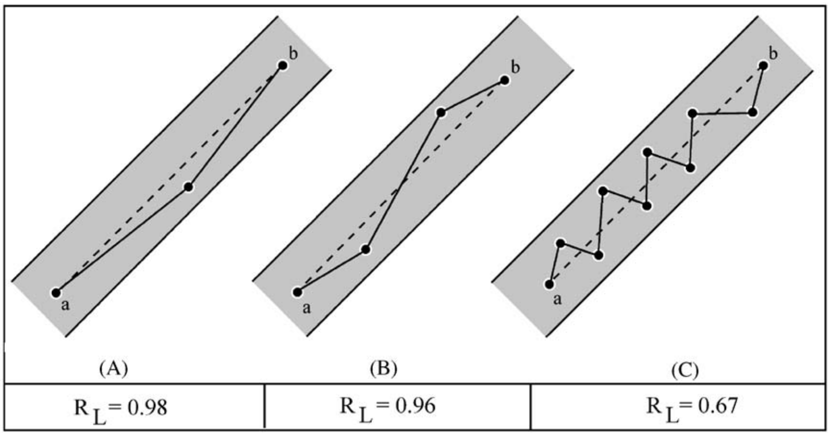

Fig. 10. (A–C) Calculation of linearity ratio (R_L = segment length/cumulative length).

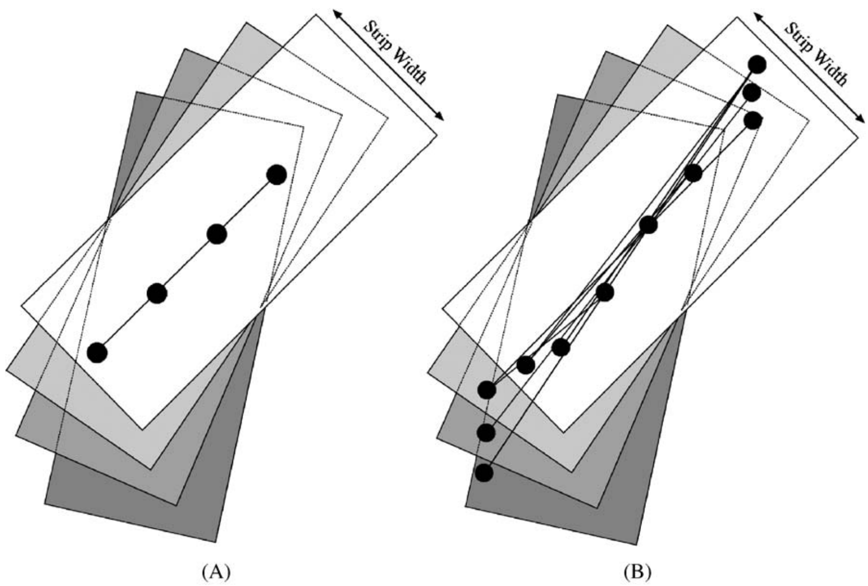

Fig. 11. Segment duplication due to repetition (A) and redundancy (B).

angle; the closest one is kept and the others are deleted from the database.

Redundant lineaments, on the other hand, are those that have some common points and are spatially similar but differ in their exact coordinates (Fig. 11B). The lineaments, therefore, are not exactly similar and occur due to the presence of different end members included in the segment. The elimination of redundant lineaments is not an easy process. Different software/programs, however, can detect such alignments by writing short scripts of formulas. The first step in this test can be the determination of "alignment deviation" from the strip direction that is referred to as redundancy check interval (RCI). If this deviation is more than 1°, for example, the alignment can be deleted from the database. This step should be followed by certain spatial analysis that can detect other similar segments.

2.8. Step 8—further analyses

The above-mentioned steps of the COSBALID method can be applied to any kind of point-like feature data to reduce the number of alignments in the "unrefined database". Forthcoming steps, on the other hand, are optional and depend on the nature of the data. Additional parameters such as morphometric characteristics (i.e. height, diameter, volume, elipticity, sphericity, orientation, and elevation), lithology, age etc. can be considered for further analysis. These parameters are used to categorize the data set. Each category can be analyzed independently based on the information for the points in the segments that are produced in steps through 1–7. Two examples of such parameters used in the application here (next section) are orientation and lithology check.

Orientation refers to the direction of the elongation of point-like features (volcanic cones here) (Fig. 12). This check is based on the assumption that elongation of the cones is a primary feature and should be parallel or sub-parallel to the azimuth of the segment. Orientation of the feature exists in the database (Fig. 2A) and is the azimuth of the long axis. During the application of this test a threshold value should be defined by the user (e.g. 20°). The acute angle between the azimuth of the feature and the direction of segment should be tested for this threshold. Segments with a greater value than the threshold are omitted from the database.

A lithology check is used to determine the lithologicaly homogeneous segments. This test is based on the assumption that a lineament consists of similar lithologic characteristics. The user can define whether 100% or any other percentage of the cones should be of the same lithology.

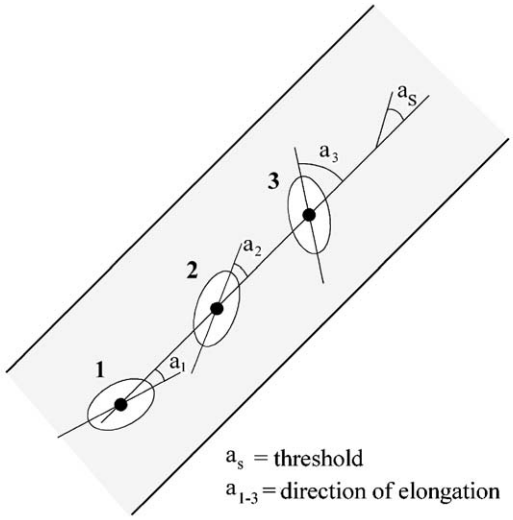

Fig. 12. Elongation check applied for elliptical features.

2.9. Step 9—generation of final lineament map

A final lineament map is prepared after all steps and evaluations are performed. This map is generated using x and y coordinates of the first and the last points of each segment (Fig. 2G). This final output might be stored in a vector or raster format for further GIS applications.

3. Application of the method

The COSBALID method is applied to the volcanic cones of the Cappadocian Volcanic Province (CVP) in central Turkey. The CVP is a Neogene-Quaternary volcanic field that extends in NE-SW direction for a length of 300 km and a width of 40 km (Fig. 13). One of the most striking features of the CVP is the presence of numerous polygenetic volcanoes and monogenetic cones scattered throughout the province (Toprak, 1998; Arcasoy, 2001). Most of monogenetic volcanoes are morphologically well preserved and are in the form of basaltic cinder cones, rhyolitic domes or maars. They are observed around major eruption centers which are exposed in the form of stroto-volcano or caldera (Fig. 13). Arcasoy (2001) identified a total of 549 volcanic cones within the province. The COSBALID method is applied to the cluster located in the center part of the province that covers 94 volcanic cones (shaded area in Fig. 13).

An initial database that contains the attributes illustrated in Fig. 2A is created for these volcanic cones. The strip width is selected of 1000 m. This divides the area into 68 strips. Accordingly, a total of 12,240

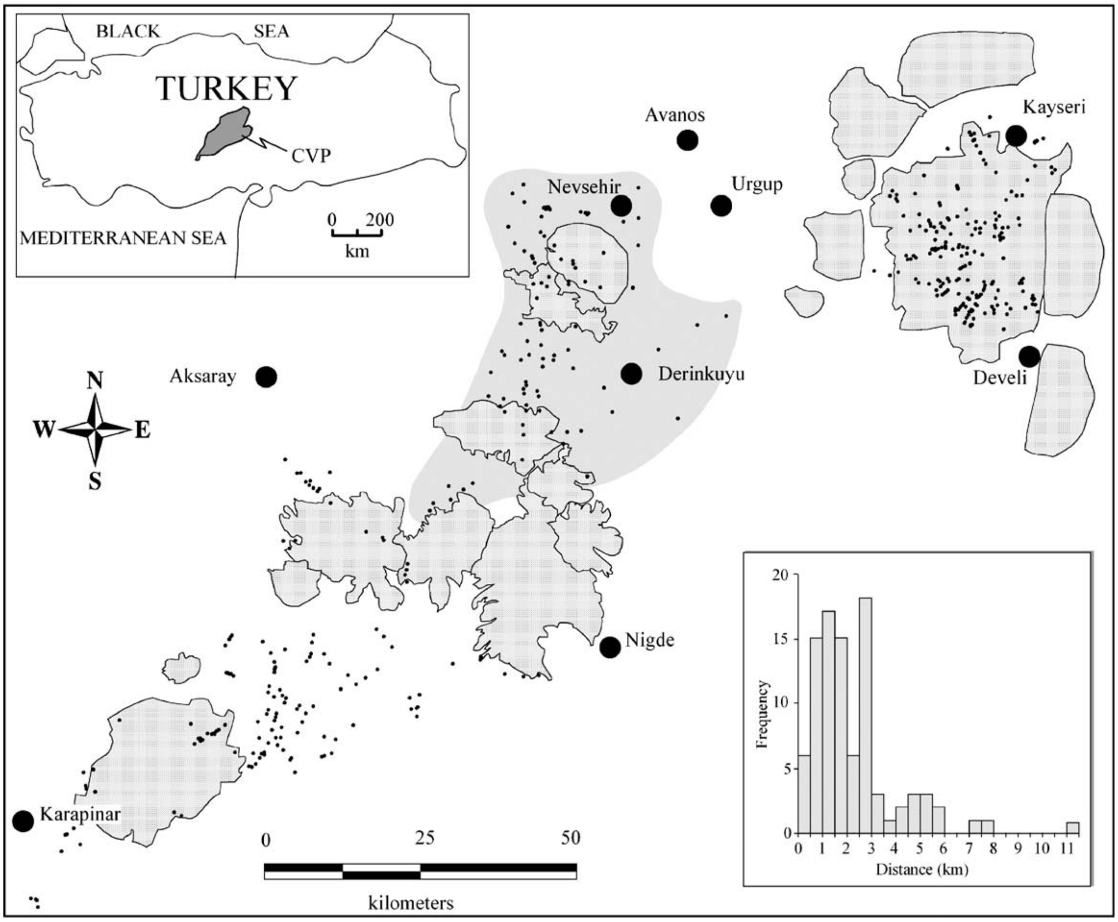

Fig. 13. Distribution of volcanic cones of Cappadocian Volcanic Province (black circles). COSBALID method is applied to central cluster in gray area. Stippled polygons are major eruption centers (after Toprak, 1998; Arcasoy, 2001). Inset diagram is histogram of "proximity analysis" that shows frequency of closest distances among cones.

(68 strips $\times$ 180°) polygons are generated and attributes of the volcanic cones are transferred by overlay analysis in a GIS environment. This is Step 3 of the COSBALID method (Fig. 1) which created a "strip database" where there are more than two points in each strip. In the next step, the points in each strip are geographically sorted to produce "unrefined alignments" (Step 4 in Fig. 1). A total of 2485 preliminary alignments exist in the database of unrefined alignments (Fig. 14A).

The alignments are later tested by the "distance filter" to eliminate "distant" cones from the database (Step 5). A distance of 5 km is selected for this application which corresponds to three times the median of the cone proximity (inset in Fig. 13). This process reduced the number of the segments to 793 (Fig. 14B).

A linearity check is applied to the alignments using a threshold value of 0.9 for a linearity ratio (Step 6). This process eliminated almost one-third of alignments and reduced the total number to 546 (Fig. 14C).

The repetition and redundancy check is the next step (Step 7) used to eliminate identical or similar lines detected in different angles at different strips. The RCI is 1°. The resultant number of the useful segments is 116 after these two tests are applied (Fig. 14D).

The verification of the lineaments using other parameters, in this application, involves lithology and elongation of the cones (Step 8). These two parameters are already included in the initial database (Fig. 2A). For the lithology check, a minimum of 50% of the cones is assumed to be of the same type. Therefore, any alignment with mixed lithologies is deleted from the database. As a result, a total of 65 alignments are assigned to the database after this test. Among these alignments, 3 are rhyolite dominating, 6 andesite dominating and 56 basalt dominating.

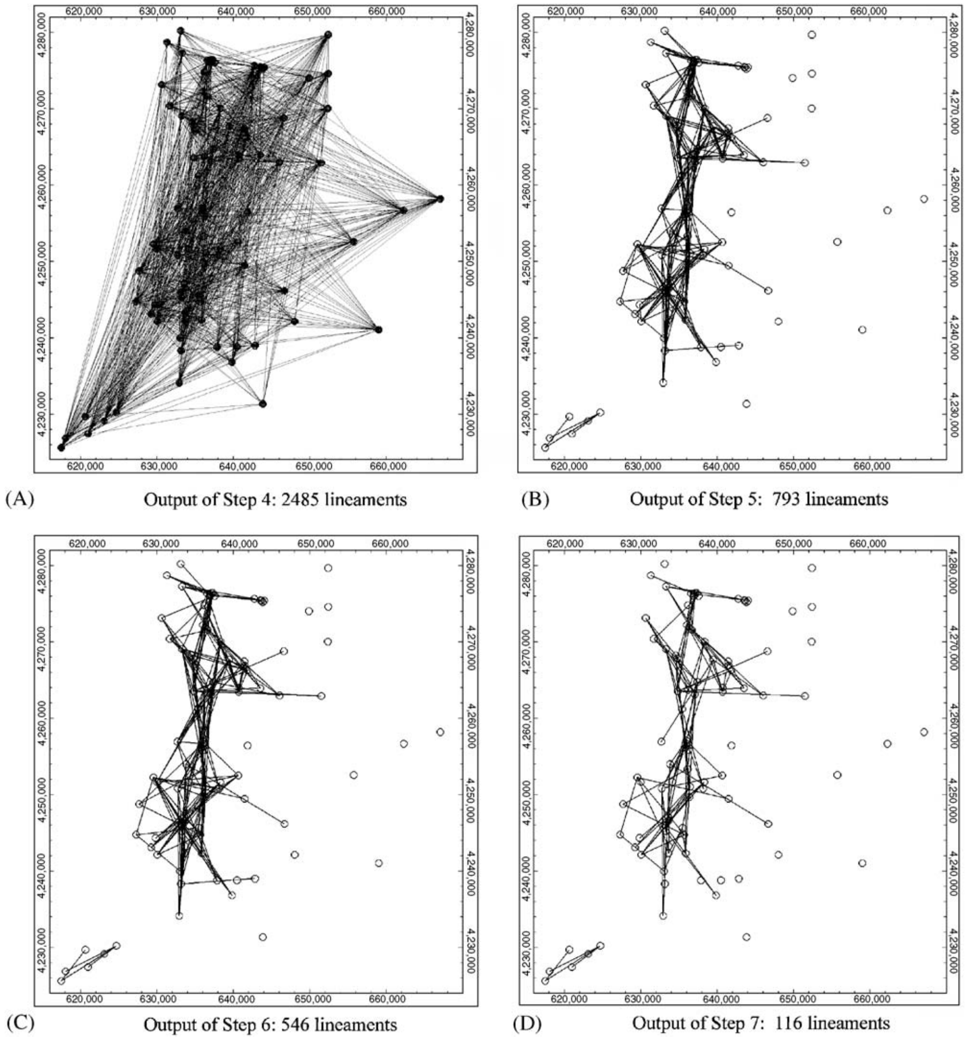

Fig. 14. (A–D) Outputs of successive steps of COSBALID method applied to cones of Cappadocian volcanics.

An orientation check is applied to the elongated volcanic cones taking the azimuth of the long axis of the cones into consideration. A threshold value of $\pm 22.5^{\circ}$ is used as the maximum deviation from the main direction (i.e. the strip direction). This test is applied to the 65 remaining alignments. Forty of these are therefore eliminated due to inconsistent elongation direction. Among the rest of the 25 alignments there is at least one cone that fulfilled the elongation requirement. This number is the final number of alignments detected after all filters and tests are applied.

The final lineament map is generated by overlaying alignment maps produced by the direction of elongation according to lithology (Fig. 15). A summary of the application that shows gradual decrease in the number of alignments as the method progresses is given in Table 1.

4. Discussion and conclusions

The main objective of the COSBALID method is to detect lineaments which could represent linear features (faults, fissures, joints etc.) on earth's surface from point-like features. Although, the ''strip concept'' is not new (e.g. Zhang and Lutz, 1989), the concepts presented in this paper are new, distinctive, and consider various aspects of lineament detection using point-like features. The most important contribution of COSBALID is that it does not consider the point-like features (i.e. volcanic cones) as mere points with coordinates but takes their geometrical and geological parameters into consideration as well.

The method is composed of several successive steps, each generating a new database to be used in the next step. Step 3 produces an initial database that lists all

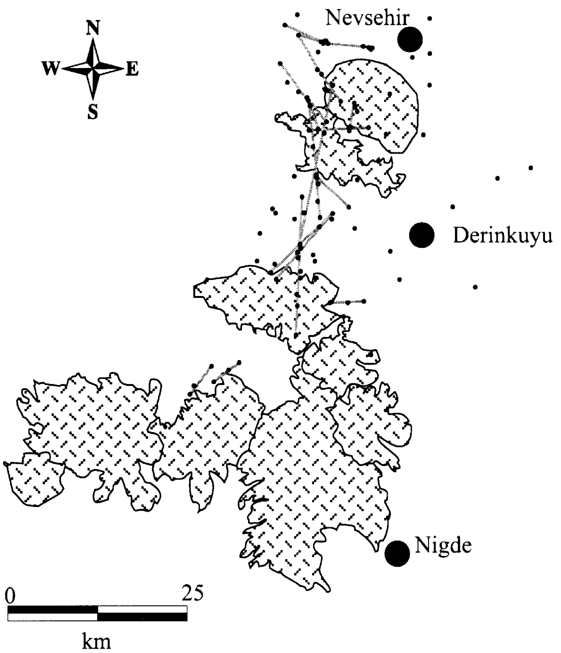

Fig. 15. Final alignments of volcanic cones produced after orientation and lithology verifications.

Table 1
Detected segments after each step in COSBALID method

Step No.	Step description	Number of segments	Threshold/ verification
3–4	Unrefined segments	2485	Strip width: 1 km
5	Distance filter	793	5 km
6	Linearity check	546	LR: 0.9
7	Repetition and redundancy check	116	RCI: ± 1
8	Lithology check	65	50% of the same type
8	Cone elongation check	25	$\pm 22.5^\circ$ deviation

possible alignments detected within all strips. Then, a minimum number of points in a segment can be specified for a segment to be considered as a lineament. This number is taken as 3 during the application of the method in this study. Progressive steps attempt to filter the initial lineaments into geologically meaningful ones using various techniques with pre-determined threshold values. These threshold values are (1) distance between the points, (2) diameter of the point-like features (here, cones), (3) linearity of cones within each segment and (4) azimuthal difference between the segment and its corresponding strip.

Advantages of the COSBALID method over existing models include:

(1) The algorithm of the method consists of several successive steps, each performing a specific task. Each step is generating a database to be used by the successive step. Any modification in the algorithm of the method, will not negatively affect the main structure of the method.
(2) The size and shape of the investigated area is not important. There is no bias implied by the shape, as is the case in the TPA method. Similarly, clustering of the data is not important during the data processing, which is mostly the initial step in other existing models.
(3) Other properties of the point-like features are considered in the method rather than only their coordinates (positions). The parameters used in this study are size, elongation, lithology and proximity of cones. Other available parameters for a different region, such as age, could easily be integrated into the method.
(4) The method delineates the alignments by taking the end points within a strip. This is one of the most striking and distinguishing characteristics of the method.

The method can be applied to detect alignments using different sets of point-like features. Examples of such data sets are springs, earthquakes, landslides, sinkholes, etc.

The most important difficulty during the application of the method is the determination of thresholds. Four of these thresholds existing in the main part of the method are determination of strip width (Step 3), distance filter (Step 5), linearity ratio (Step 6) and redundancy check interval (Step 7). A misjudgment of the threshold, however, is not necessarily a weakness of the method. The user decides on the threshold assignments based on specific conditions existing in the area, trial and error, or statistical analyses.

Acknowledgements

This study is partially supported by TUBITAK (Project No: YDABCAG-551) and METU (Research Project No: 99-03-99-04). We would like to thank Dr. Lutz for his valuable comments and contribution. We would also like to thank to Penny Er for improving the manuscript.

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