Buffers - Specific Theory

Introduction

Buffering involves the creation of a zone of a specified width around a point, line or polygonal area. The resulting buffer is a new polygon, which can be used in queries to determine which entities occur either within or outside the defined buffer zone. (Burrough & McDonnell, 1998, p 299).

Buffering can also be defined as the vector equivalent to distance analysis in raster Geographical Information Systems.

Buffering of Point Data

GIS operations often require a point, line or polygon to be 'buffered' for analysis purposes. Buffering point data is the simplest form of buffering, as the process simply involves the creation of a 'circular' polygon about each point of radius equal to the buffer width. There are two methods of assigning buffer width. The first (and simplest) uses a fixed buffer distance for all points in a layer. The second allocates each point an individual buffer distance based on attributes present in the table of that layer in the system (i.e. weighted).

If there are multiple points in the layer being buffered, then the system must check for overlaps in each point's buffer. Any overlapping sections must be removed – so that the result of the operation are polygons representing the area covered by all overlapping buffers. This process involves two additional operations: intersection and dissolve.

The buffering process results in a new layer in the system consisting of polygon data which represents the buffered zones – of either fixed or weighted distance. The resulting polygon table will have identifiers for each of the polygons created in the buffering process, and an additional attribute indicating if the particular polygon lies inside the buffer zone or outside the buffer zone.

Buffering of Line Data

GIS operations often require a point, line or polygon to be 'buffered' for analysis purposes. The algorithm for buffering line data is more complex than that for buffering point data, as lines can be made up of multiple segments. The process for buffering a single line is as follows:

- First assign each line segment the appropriate buffer width (which may be fixed for all lines or weighted). Call this buffer distance **b**.
- Each line segment has a start node **(E_1,N_1)** and end node **(E_2,N_2)**. Using these coordinates **Δx** and **Δy** between the two endpoints are computed.
- Endpoints of parallel buffer lines which lie on either side of the line segment at perpendicular distance **b** are determined using the following formulae:

$$\mathbf{E_1 \pm b.sin[tan^{-1}(\Delta x / \Delta y)]}$$
$$\mathbf{N_1 \pm b.cos[tan^{-1}(\Delta x / \Delta y)]}$$

and

$$\mathbf{E_2 \pm b.sin[tan^{-1}(\Delta x / \Delta y)]}$$
$$\mathbf{N_2 \pm b.cos[tan^{-1}(\Delta x / \Delta y)]}$$

Note that if the line is horizontal or vertical with respect to the system axis, then these formulae become much simpler. At this point the system tests the line segment tangent value to determine wether Easting and Northing increments are added or subtracted depending on the line direction.

- Once the two new parallel buffer lines have been identified, the next line segment can be processed in the same manner.
- Once the parallel buffer lines have been identified for the next segment, the line intersections of the parallel buffer lines of each segment are calculated and new coordinates are assigned to the common vertices. The simplest line intersection test can be used here – as there will always be a solution.
- These steps are repeated until the final segment has been processed.
- The final step involves defining the ends of the buffer - at the lines start and end points.

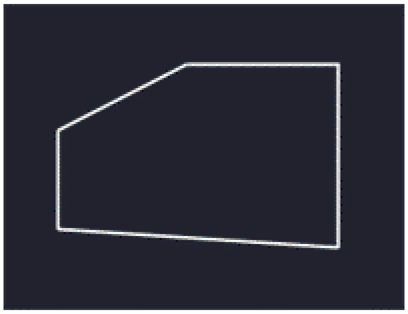
Different GIS software packages may define the ends of a buffer differently. Methods are:
1. Simple Truncation of the parallel buffer ends.
2. Tapering of the parallel buffer ends to meet at the end-points.
3. 'Capping' the start point and end point of the line with 'half-circular' polygons of buffer radius **b**.

If there are multiple lines in the layer being buffered, then the system must check for overlaps in each line's buffer. Any overlapping sections must be removed – so that the result of the operation are polygons representing the area covered by all overlapping buffers. This process involves two additional operations: intersection and dissolve.

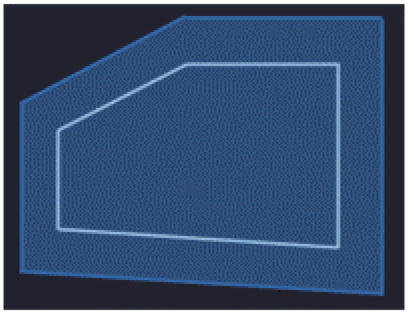
The buffering process results in a new layer in the system consisting of polygon data which represents the buffered zones – of either fixed or weighted distance. The resulting polygon table will have identifiers for each of the polygons created in the buffering process, and additional attributes: indicating the buffer distance, and indicating if the particular polygon lies inside the buffer zone or outside the buffer zone.

Buffering of Polygon Data

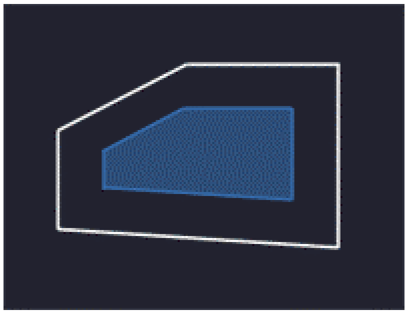
GIS operations often require a point, line or polygon to be 'buffered' for analysis purposes. The algorithm for buffering polygon data uses the same process as the line buffering algorithm, with one small difference – the polygon buffer is created on only one side of the line which defines the polygon. The default method is to create a buffer which surrounds the polygon boundary – some GIS software packages also give an option to create a buffer that lies inside the polygon boundary. Below is an example of the possible outputs of buffering a polygon.



Original Polygon



Outside Polygon Buffer (50 units)



Inside Polygon Buffer (50 units)