[AM-02-003] Buffers

Abstract

This short article introduces the definition of buffer and explains how buffers are created for single or multiple geographic features of different geometric types. It also discusses how buffers are generated differently in vector and raster data models and based on the concept of cost.

Keywords: basic analytical operations, distance, neighborhoods, proximity

Author & citation

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Explanation

One of the most common tasks in our daily life is to find out what is proximal to or within the neighborhood of a location. For example, travelers would like to know the restaurants and points of interest that are within a certain walking or driving distance and a conservationist wants to create riparian buffer zones to protect streams from the impact of adjacent land uses (Xiang, 1993). Those questions can be answered by using buffer, one of the most basic geographic information science (GIS) analytic operations.

The buffer of a geographic feature is an area where the shortest distance from any location within the area to the feature is less than or equal to a threshold distance. Whether the geometric type of a geographic feature is point, line, or polygon, its buffer is always a polygon (Figure 1). The boundary of the buffer polygon can be generated based on the buffers of the two most fundamental geometric features, points and line segments. The buffers for a point and a line segment (without the two endpoints) are a circle and a rectangle, respectively. The buffers for more complex linear and polygon geographic features are generated by creating and combining the circles and rectangles of the points and line segments representing the geographic features.

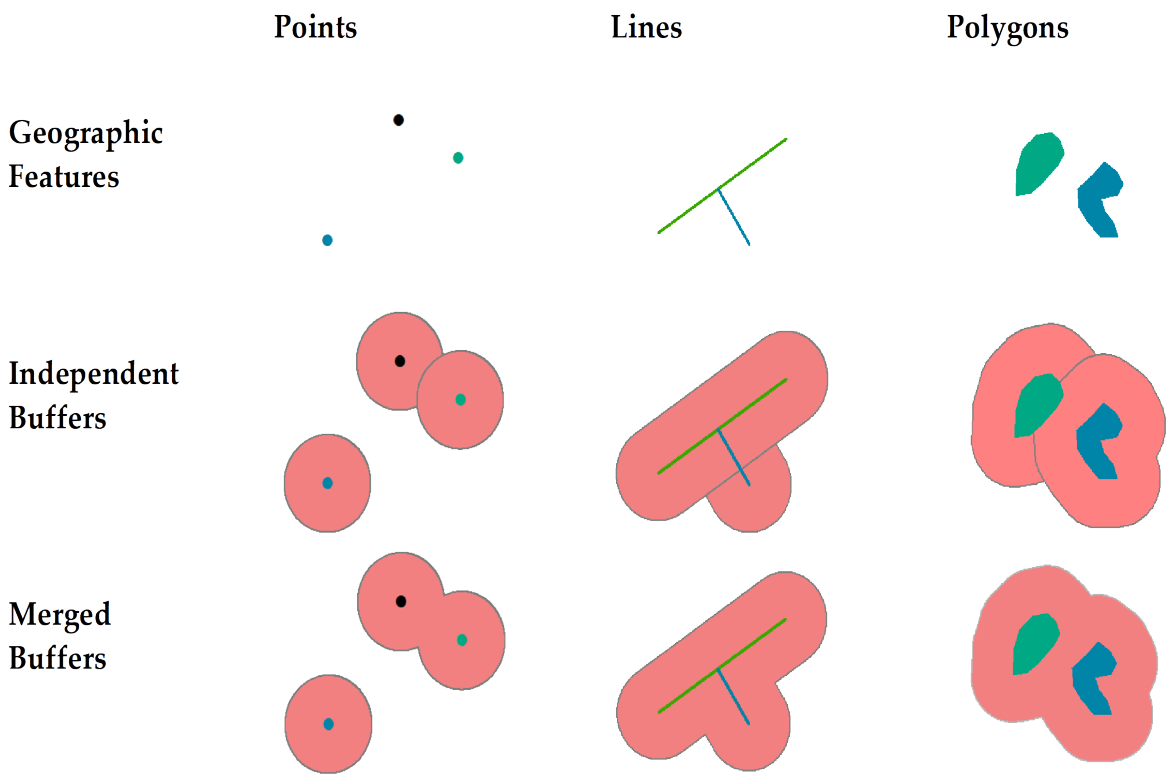


Figure 1. Independent and merged buffers for geographic features of different geometric types.

When creating the buffers for a set of geographic features, some of the buffers may overlap in space. Those buffers can be kept either as independent buffers associated with each geographic feature or merged into a single buffer for the entire set of geographic features (Figure 1). In addition, buffer distance may vary from feature to feature within a set of geographic features. GIS can generate buffers based on the specific distance associated with a feature, which is usually stored as a property of the features.

Buffers can also be generated in the raster data model. In some cases, vector geographic features are first converted to a raster layer and represented by raster cells (hereafter feature cells). The shortest distance from each cell to any of the feature cells is calculated and saved in a distance raster layer. Buffers are then delineated by choosing those cells whose distance to the feature cells is less than or equal to a specific buffer distance (Figure 2). If we visualize the distance raster layer as a surface where the feature cells are at the bottom of the valley, the boundary cells surrounding the buffer would have roughly the same distance value as the buffer distance and therefore follow a contour on the surface. There is a difference in the ways buffers are generated in the vector and raster data models. While the vector data model strives to locate the buffer boundary directly, the raster data model expands (or grows) the buffer by examining and accumulating locations (or cells) based on their distance to the features.

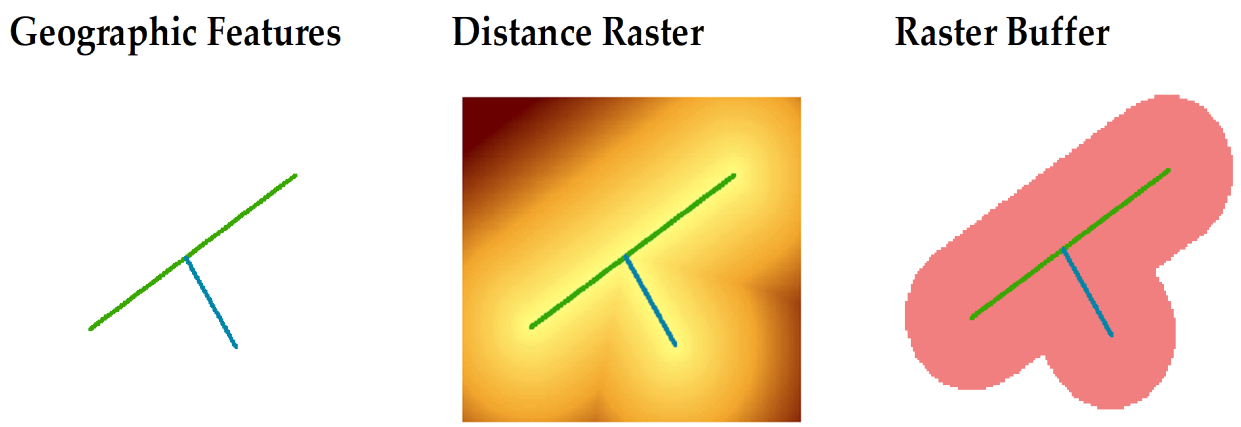


Figure 2. Generating buffers in the raster data model.

Distance calculation is a critical step in generating buffers. While the familiar Pythagorean Theorem can be used to calculate distance in Euclidean space, distance can also be measured on networks (Upchurch et al., 2004), such as the distance traveled on roads or in rivers, or in non-Euclidian space, such as the geodetic distance (Karney, 2013) on a spheroid surface, which is often used to represent the shape and size of the Earth. More generally, distance can be conceptualized as the cost of overcoming movement friction, which may contain barriers, vary in space and time, and depend on movement direction (Li et al., 2005). In such cases, distance becomes the least cost incurred by traveling between two locations in space (Douglas, 1994; Tomlin, 2010). Buffers, therefore, can be generated as the area covered by a certain time traveled, energy spent, or, more generally, cost incurred and also manifested in the geographic space in GIS.

References

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