Dot Density Maps

Dot density maps, or dot maps, portray the geographic distribution of discrete phenomena using an arrangement of identical point symbols, most commonly dots. The dot density technique dates to at least the 19th century and is today accepted as one of the primary techniques for representing geographic patterns. Dot density maps are particularly useful for understanding global distribution of the mapped phenomenon and comparing relative densities of different regions on the map. Dot density maps are also easy to understand, requiring little cognitive effort by the map reader when compared to isoline maps. However, retrieval of specific information from dot density maps is difficult, as map users find manual counting of dots tedious and tend to underestimate dot totals as density increases.

Types of Dot Density Maps

There are two kinds of dot density maps: one-to-one maps and one-to-many maps. For one-to-one dot density maps, each point on the map corresponds to a single incidence of the mapped phenomenon. One-to-one dot density maps are general-reference maps, symbolizing spatial location only. Because of this, care should be taken to ensure that the dot is accurately located on the map. Examples datasets ideal for one-to-one dot density mapping include the major cities in Europe or locations of recent earthquakes along the Pacific Rim.

Although one-to-one dot density maps are more common in practice, the term dot density map typically refers to one-to-many dot density maps. For one-to-many dot density maps, each point on the map represents a pre-determined number of incidences of the mapped phenomenon, called the dot value. One-to-many dot density maps are thematic maps, symbolizing an aggregated variable atop a reference base map. Use of a one-to-many dot density map, rather than the one-to-one counterpart, is necessary when the only available data is aggregated to areal enumeration units or there are too many point incidences within the map extent for legible representation, necessitating aggregation by the cartographer. Example datasets ideal for one-to-many dot density mapping include the population of the US and the number of dairy cows in Wisconsin, both aggregated by county.

Aggregated Data and One-to-Many Dot Density Maps

Not all aggregated data is appropriate for one-to-many dot density mapping. Alan MacEachren and David DiBiase developed a typology of aggregated data based on two characteristics of the mapped phenomenon: (1) if the phenomenon occurs at discrete locations in space or if it exists continuously throughout the map extent and (2) if the phenomenon changes abruptly at enumeration boundaries or if varies smoothly throughout the map extent. Each data model is then paired with a recommended mapping technique. Figure 1 provides simple and effective guidance for determining the appropriate thematic map technique for representing aggregate data given the characteristics of the mapped phenomenon. Only aggregated data of phenomena that exists discretely in space and varies smoothly across space should be mapped using the dot density technique. Only magnitude data should be displayed with dot density maps; derived values, such as averages, rates and percentages, are theoretically continuous and should therefore be mapped with a choropleth.

FIGURE 1 HERE

Figure 1: A reference for matching mapping technique to aggregated dataset based on the characteristics of the mapped phenomenon.

Source: MacEachren, AM. (1992). Visualizing Uncertain Information. *Cartographic Perspectives, 13.* P.16. Adapted with permission from Alan MacEachren and The North American Cartographic Information Society.

One-to-Many Dot Density Map Design Considerations

There are four important design considerations for one-to-many dot density maps that impact the accuracy, clarity, and effectiveness of the image: (1) units of aggregation, (2) dot size, (3) dot value, and (4) dot placement. The size, shape, and distribution of enumeration units at which the data is aggregated can influence the mapped pattern greatly. Generally, the smaller the size and more regular the shape and distribution of enumeration units, the more realistic the mapped pattern. When possible, enumeration units that are meaningful to the mapped phenomenon should be used over those that are arbitrary.

The dot size and dot value should be considered in tandem and together determine the number of dots on the map. An intermediate dot size should be chosen in most cases; dots that are too small produce an overly sparse dot pattern and convey an inappropriate amount of map accuracy, while dots that are too large produce excessively dense dot patterns, overwhelming subtleties in the distribution of the mapped phenomenon. A rounded, easily understood number should be chosen for the dot value for easy estimation. Selection of an appropriate dot size and dot value always requires some experimentation, but can be made easier by using a visual tool called a nomograph. When an appropriate dot value and dot size are chosen, there should be 2-3 dots in the enumeration units with the smallest values and the dots should just begin to coalesce in enumeration units with the largest values.

The final important design consideration for one-to-many dot density maps is the method for placing dots in the enumeration units. Most mapping software now allows automated, random placement of dots. However, random placement does not take into account the distribution of the mapped phenomenon and may lead to spurious clustering on the map. There are two recommended alternatives: (1) a geographically weighted approach which shifts dots towards neighboring enumeration units with higher values and away from those with lower values and (2) a geographically based approach that uses ancillary information about the mapped phenomena to negatively weight dot placement in prohibitive areas and positively weight dot placement in suitable areas. Uniform placement of dots produces abrupt, unwanted boundary effects and should therefore be avoided.

Robert E. Roth

See also: Cartography, Choropleth Maps, Dasymetric Maps, Alan MacEachren, Map Design

Further Readings

Dent, B. 1999. *Cartography: Thematic Map Design*. 1999. Boston, MA: McGraw-Hill.

MacEachren A.M. & D. DiBiase. 1991. Animated Maps of Aggregate Data: Conceptual and Practical Problems. *Cartography and Geographic Information Systems*, *18(4)*, 221-229.

Slocum, T.A., R.B. McMaster, F.C. Kessler, & H.H. Howard. 2005. *Thematic Cartography and Geographic Visualization*. Upper Saddle River, NJ: Prentice Hall.