METHODS OF DIGITIZATION

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Digitization is a process of converting the geographic features on an analog map into digital format using a digitizing tablet, or digitizer, which is connected to a computer. Features on a paper map are traced with a digitizer puck, a device similar to a mouse, and the x,y coordinates of these features are automatically recorded and stored as spatial data. During the digitizing process, features from the traced map or image are captured as coordinates in either point, line, or polygon format. With reference to the spatial information digitization can the process of creating a vector creating a vector digital database by creating point, line and polygon objects. In the following, we explain the commonly used methods for getting vector data, their advantages and drawbacks.

1. Manual digitizing

Manual digitizing using a digitizing tablet has been widely used. A digitizing tablet is an electronic device consisting of a table upon which the map or drawing is placed. With this method, the operator manually traces all the lines from his hardcopy map using a pointer device (digitizer puck) and create an identical digital map on his computer. A line is digitized by collecting a series of points along the line. While tracing the features the coordinates of selected points, e.g. vertices, are sent to the computer and stored. All points that are recorded are registered against positional control points, usually the map corners, that are keyed in by the user at the beginning of the digitizing session. The coordinates are recorded in a user defined coordinate system or map projection. Latitude and longitude and UTM is most often used. The ability to adjust or transform data during digitizing from one projection to another is a desirable function of the GIS software.

Manual digitizing has many advantages. These include:

- Low capital cost, e.g. digitizing tables are cheap;
- Flexibility and adaptability to different data types and sources;
- Easily taught in a short amount of time - an easily mastered skill

Although this method is straight forward, it requires experienced operator and is very time consuming. For a complex contour map, it can take a person 10 to 20 days to get the map fully digitized.

Another major drawback of this method is its low accuracy. The accuracy of manual digitizing merely depends on how accurate the hardcopy map is duplicated on a

computer by hand. The spatial accuracy level the human hand can resolve is about 40 DPI (dots per inch) in the best case and will be lower while the operator is tired and bored after working on it for a period of time. One experiment was done at a university, a group of geography students were asked to digitize the same map and the final digitized maps were overlaid on top of each other to create a new map. The result is not surprising, the new map is heavily distorted as compared to the original map. Manual digitizing is supported by most GIS packages with direct link to a digitizing tablets through a computer I/O port.

2. Heads-Up Digitizing and Interactive Tracing

Heads-up digitizing is similar to manual digitizing in the way the lines have to be traced by hand, but it works directly on the computer screen using the scanned raster image as backdrop. While lines are still manually traced, the accuracy level is higher than using digitizing tablet because the raster images are scanned at high resolution, normally from 200 DPI to 1600 DPI. With the help of the display tools, such as zoom in and out, the operator can actually work with the resolution of the raster data therefore digitize at a higher accuracy level. However, the accuracy level is still not guaranteed because it is highly dependent on the operator and how he digitizes. This method is also time-consuming and takes about same amount of time as the manual digitizing method.

The interactive tracing method automates individual line tracing process by tracing one line at a time under the guidance of the operator. This is a significant improvement over manual heads-up digitizing in terms of digitizing accuracy and speed, especially when fully automatic raster to vector conversion can not be applied in cases such as low image quality and complex layers. The main advantage of using interactive tracing is the flexibility of tracing lines selectively and better operator control.

- Low cost of labour;
- Generally the quality of data is high;
- Digitizing devices are very reliable and most often offer a greater precision that the data warrants; and
- Ability to easily register and update existing data.

3. Automatic Raster to Vector Conversion

Automatic digitizing or so called automated raster to vector conversion, traces lines automatically from the scanned raster image using image processing and pattern recognition techniques. The idea behind automated raster to vector conversion

algorithm is to let the computer do the actual line tracing and eliminate tedious manual tracing the human operator has to do. Because of the importance to automate raster to vector conversion process and the difficulties involved, it has been a major research focus during the past two decades. Only in recent years, automated raster to vector conversion software on PCs and small computers become practical and commercially available for data acquisition applications.

A variety of scanning devices exist for the automatic capture of spatial data. While several different technical approaches exist in scanning technology, all have the advantage of being able to capture spatial features from a map at a rapid rate of speed. However, as of yet, scanning has not proven to be a viable alternative for most GIS implementation. Scanners are generally expensive to acquire and operate. As well, most scanning devices have limitations with respect to the capture of selected features, e.g. text and symbol recognition. Experience has shown that most scanned data requires a substantial amount of manual editing to create a clean data layer. Given these basic constraints some other practical limitations of scanners should be identified. These include :

- hard copy maps are often unable to be removed to where a scanning device is available, e.g. most companies or agencies cannot afford their own scanning device and therefore must send their maps to a private firm for scanning;
- hard copy data may not be in a form that is viable for effective scanning, e.g. maps are of poor quality, or are in poor condition;
- geographic features may be too few on a single map to make it practical, cost-justifiable, to scan;
- often on *busy* maps a scanner may be unable to distinguish the features to be captured from the surrounding graphic information, e.g. dense contours with labels;
- with raster scanning there it is difficult to read unique labels (text) for a geographic feature effectively; and
- scanning is much more expensive than manual digitizing, considering all the cost/performance issues.

The building of topology is primarily a post-digitizing process that is commonly executed in *batch mode* after data has been cleaned. To date, only a few commercial vector GIS software offerings have successfully exhibited the capability to build topology interactively while the user digitizes.