Map Scanning and Automated Conversion

Objectives (Entry)

This unit will introduce quick and less costly method of data capture - map scanning and automated conversion. This unit will briefly discuss about scanners. This unit will thoroughly discuss scanning of document, vectorizing through on-screen digitizing, automated and semi automated conversion with practical exercises using R2V software. At the end of the unit, the student will be able to carry out to capture the spatial data through scanned documents using onscreen digitizing, automated and semi-automated conversion methods.

Map Scanning and Automated Conversion (Clarification)

Compared to manual digitizing, scanning is very quick and less costly. The result of scanning an existing document or map is a raster image, recording a value of dark or light for each grid cell or pixel of the scan. Due to the raster format, scanned images are not directly useful in the vector GIS. However, the scanned image can be display as the background image after georeferencing.

The pattern recognition algorithms have been developed to recognize line, symbol and annotation from the scanned image to the vector format. Moreover, editing and translation software, are available to convert to vector format.

1. Scanners

Scanner converts existing maps, documents, and aerial photographs into a digital raster format. The scanning process can be done at black and white mode or gray scale mode (2 bit, 8 bit, 16 bit) or color mode (4 bit, 8 bit, 16 bit). Scanning resolution varies from 75 to 3000 dots per inch (dpi). Each dot is a pixel. The value of each pixel or dot represents the gray scale intensity or color of it. The type, quality, information content, condition of source document, and application purpose determine the resolution and mode of scanning.

Scanners use optical techniques to sense variations in reflected light or tone from the surface of documents to duplicate in a digital format from paper or other hard copy map products. Therefore, all the point, line, text, symbol, stains, hand writing, wrinkles on the document surface will be encoded as information by the scanner. The scanner records the values of darker tones that represent the graphics, text or drawing and the values of lighter tones for non graphics, non text and non symbol, for each pixel or dot of the scan.

There are three basic types of scanner: flatbed scanners, rotating drum scanners, and pass through scanners. In flatbed scanners, the hard-copy document is placed on a flat, horizontal surface, and the scan head moves along y axes over the document. In rotating drum scanners, the document is mounted on a cylinder that rotates while the scan head moves horizontally across the cylinder. Most of the rotating scanners are scanners as well as plotters. The pass-through scanners accept a document that is fed through a slot and read the reflectance tone by the scan head, line by line.

Scanners have two basic types of operation: Reflective and Transmissive. Reflective scanners are used to scan opaque document such as paper map or aerial photograph. Transmissive scanners are used to scan transparent documents such as Mylar map separates and photographic diapositives.

The scanning resolution is the most important specification to evaluate the scanner for Data Capture. The resolution should be matched with the content and complexity of the Map, Aerial Photograph or documents. It will discuss more detail in Scanning Document Section.

2. Scanning Document

The Map, aerial photographs and CAD drawings are majority documents to scan and convert to GIS spatial database.

Before scanning a document, resolution of scanning must decide because the scanning resolution or pixel resolution or dpi is directly linked to information content, quality of information, project data quality standard, coordinate measurement accuracy and data volume or file size.

The following table illustrates the relationship between pixel scanning resolution or dpi; scale of document and pixel ground resolution.

Pixel Resolution or dpi	μm	Pixel ground resolution 1:40000	Pixel ground resolution 1:20000	Pixel ground resolution 1:5000
75	339	13.5m	6.8m	1.7m
100	254	10.2m	5.1m	1.3m
150	169	6.8m	3.4m	0.8m
200	127	5.1m	2.5m	0.6m
300	85	3.4m	1.7m	0.4m
400	64	2.6m	1.3m	0.3m
600	42	1.7m	0.8m	0.2m
800	32	1.3m	0.6m	0.16m
1000	25	1.0m	0.5m	0.13m
1200	21	0.8m	0.4m	0.11m
1500	17	0.7m	0.3m	0.07m
2000	13	0.5m	0.3m	0.07m
3000	9	0.4m	0.2m	0.05m

Higher scan resolution facilitates more accurate ground control point measurements and Georeferencing. However, the data volume or size of the file and processing time increases greatly.

With adequate control, mapping accuracy equivalent to approximately 1 pixel in X and Y can be obtained.

High resolution scanning may result too noisy image and very low resolution may not separate the minor details. Therefore, scanning at different resolution should be tested to evaluate the result in order to get the optimal solution.

The ability to read the text, the ability to separate the features based on line width, color, gray scale should be considered in evaluating the resolution of scanned image.

The resulting scanned image is not perfect even with the best possible scanners because it contains not only all the smudges and defects of the original map but also errors caused in areas where the map detail is so complex.

The digital image can be filtered to remove isolated pixels. The quality of scanned image can be improved and made it usable with thresholding or binarization in order to remove excess data from image. Thresholding or Binarization is a process that classifies all pixels from a fixed range of gray values to one level to create a binary image.

Georeferencing, scale correction, matching and alignment of scanned image can be corrected using known control point locations. The control points can be defined directly from the scanned image and processed registration to map coordinate system. The format of scanned raster image can be transformed to any raster exchange transfer format in order to use in different software.

The scanned aerial images of aerial photographs can be used directly for Digital Photogrammetry Stereo compilation; Digital Elevation Modeling from stereo pair of scanned aerial photographs and Orthophoto Mapping.

However, the scanned image is not an intelligent one to use directly in GIS. It cannot identify individual feature uniquely. It cannot link to attribute files. Only human interpretation, experience, observation and intelligence uniquely recognize the features in the scanned image.

Most GIS application requires the vector data and linkage of attributes; therefore the usefulness of scanned image is limited. Therefore vectorization of features in the scanned image is essential. Algorithms have been developed to convert rater data to the vector format and to recognize line, symbol, and annotation patterns that apply to the scanned data.

Scanning system comes with the software or third party software, that can edit scanned raster image and vector data, trace automatically or semi automatically raster lines of scanned image and converts to a vector format with line segments individually defined.

3. Vectorizing through on-screen digitizing

Features of scanned image can be converted into a series of points, lines and polygons by digitizing directly from the screen display.

After Georeferencing of the scanned raster image, it is displayed it as the screen backdrop and the geometry of various entities is defined by digitizing from the screen using a cursor controlled by the mouse.

This method has been used successfully not only with scanned maps but also digital photographs and satellite images.

The Feature Editing Prima Section of Map Digitizing Unit will be instrumental to capture the point, line and polygon features from backdrop georeferenced image.

4. Automated and semi automated conversion

Automated conversion consists of creating the vector features and associated database attributes from scanned raster image. In this process, raster image editing, recognition processing and vector editing are included.

When old and bad condition documents are scanned, the resulting scanned raster image has a lot of noise or speckle. These noise or speckles can be removed or reduced by performing some image processing functions before proceeding with vectorization.

The basic processing steps in Automated and semi automated conversion are

- Scanning the source document to create scanned image

- Recognize raster lines, symbol and characters automatically or semi automatically

- Construct vector elements and texts

- Relate the objects

- Add the data to the database

Lines and curves are represented as connected raster line in the image. The recognition process used thinning algorithms, which reduced the thick raster line to single pixel wide line. Then the center point of each pixel is selected and connected to form a vector line. These vector lines are linked using algorithms, which scan and join neighbouring pixels of the same value or user controlled operation.

The resulting vector elements require further editing to correct connectivity errors. Automatic conversion generates more erroneous vectors especially connectivity. In semi automatic conversion, the operator initiates the starting point. The recognition algorithm follows the line until it arrives at a junction or back to the first coordinate in the case of a closed polygon. If the line is traced incorrectly, the operator can delete it immediately. The operator can guide the recognition algorithm to trace correctly at the junctions.

In semi-automated conversion, a great deal of operator control is essential. Semi automated conversion is useful especially to vectorize the maps, which frequently use various dash line styles to represent different facilities and features.

Cleanup functions such as line snapping, eliminating of dangle errors such as overshoot and undershoots are also required to correct the resulting vector elements.

Character and symbol recognition programs may be used to recognize the symbol and texts. The recognition of symbol and text has been little success. The symbol recognition is not often used in automated and semi automated conversion. The text recognition algorithms, has little success with the hand written or rotated text often contains on the map.

5. Use of scanned images

Use of scanned images will continue to grow for data conversion as the scanning technology continues to improve.

The scanned images of maps are used for vectorization especially for data input to GIS Database. The electronic copy of paper map allowed the safe handling of images instead of the paper documents.

Through automated and semi-automated conversion or heads-up (on screen) digitizing, the features in the scanned images can be vectorized. The scanned aerial photographs have several uses for GIS and Digital Photogrammetry.

The scanned aerial photos can be warped to ground control point or orthorectified to produce digital Orthophoto. Rectified or orthorectified digital photos can be used for heads-up digitizing. Moreover, digital Orthophoto can be used as photomap as the actual layer of geographic data in the GIS Database.

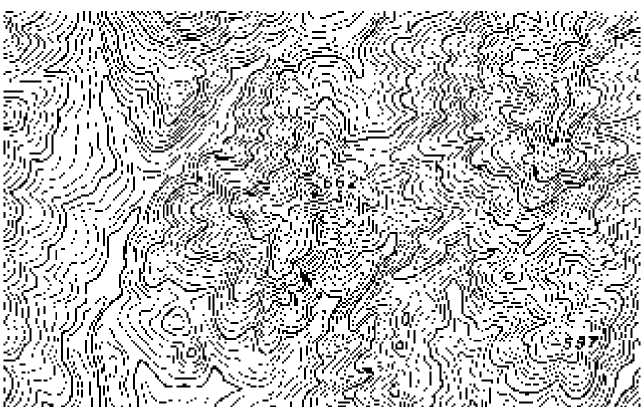
The scanned stereo pairs of aerial photographs are integral part of soft copy digital Photogrammetry to produce digital elevation model, to extract terrain information such as elevation, slope, slope length, aspect, viewshed, watershed, hill shading, cut and fill volume calculation, and to produce digital orthophotos. By viewing stereoscopic view of photo pair, heads-up digitizing can be done to obtain the stereodigitized vector data. The raster image of the photo can be overlaid with stereodigitized vector data to check the completeness and quality.

The photographs or text of features such as house, poles, bridges, transformers, Fire hydrants, access cover and road signs etc. can be scanned and link to the feature attribute tables to see real world features.

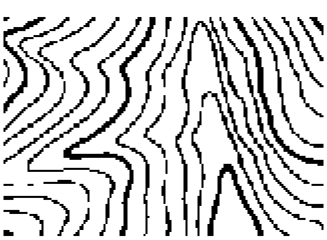
Scanned Documents Examples (Look)

The following image is 1bit bi-level image. The image contains 0,1 value. The source of the image is from

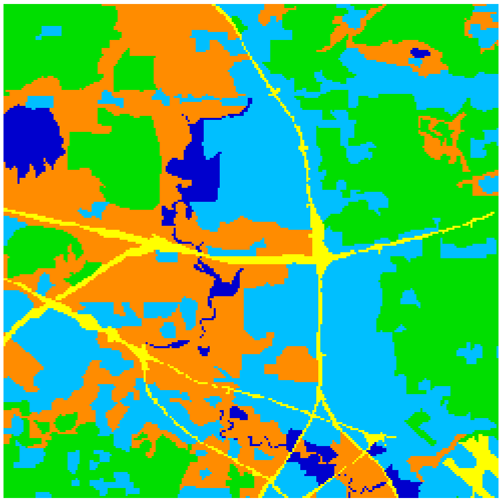
R2V Software (http: //www.ablesw.com/r2v/)



0 represents the pixels of contour, which are dark color. 1 represents the pixel of non-contour, which are white color. See the following enlarge image. The contour lines can be extracted from this scanned 1 bit bi-level image through semi-automated conversion.



The following image is 8 bit (256 color) image. The polygon and line features can be extracted from this image through semi-automated conversion or onscreen digitizing.



The following image is 8 bit grey scale scanned image. The polygon and line features can be extracted from this image through semi-automated conversion or onscreen digitizing.