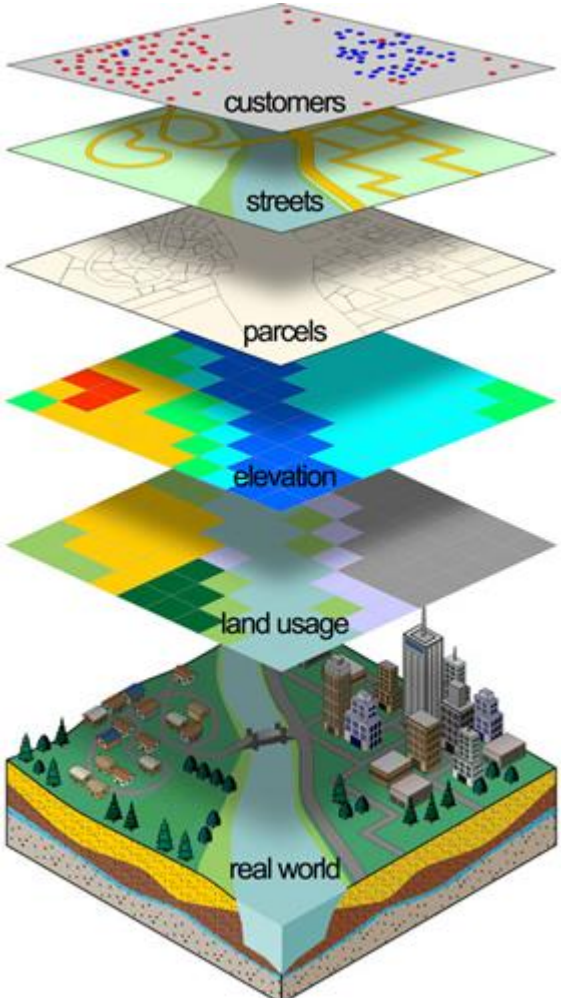
PAPER NAME-GEOGRAPHIC INFORMATION SYSTEM

COURSE CODE-GEOGP503SEC



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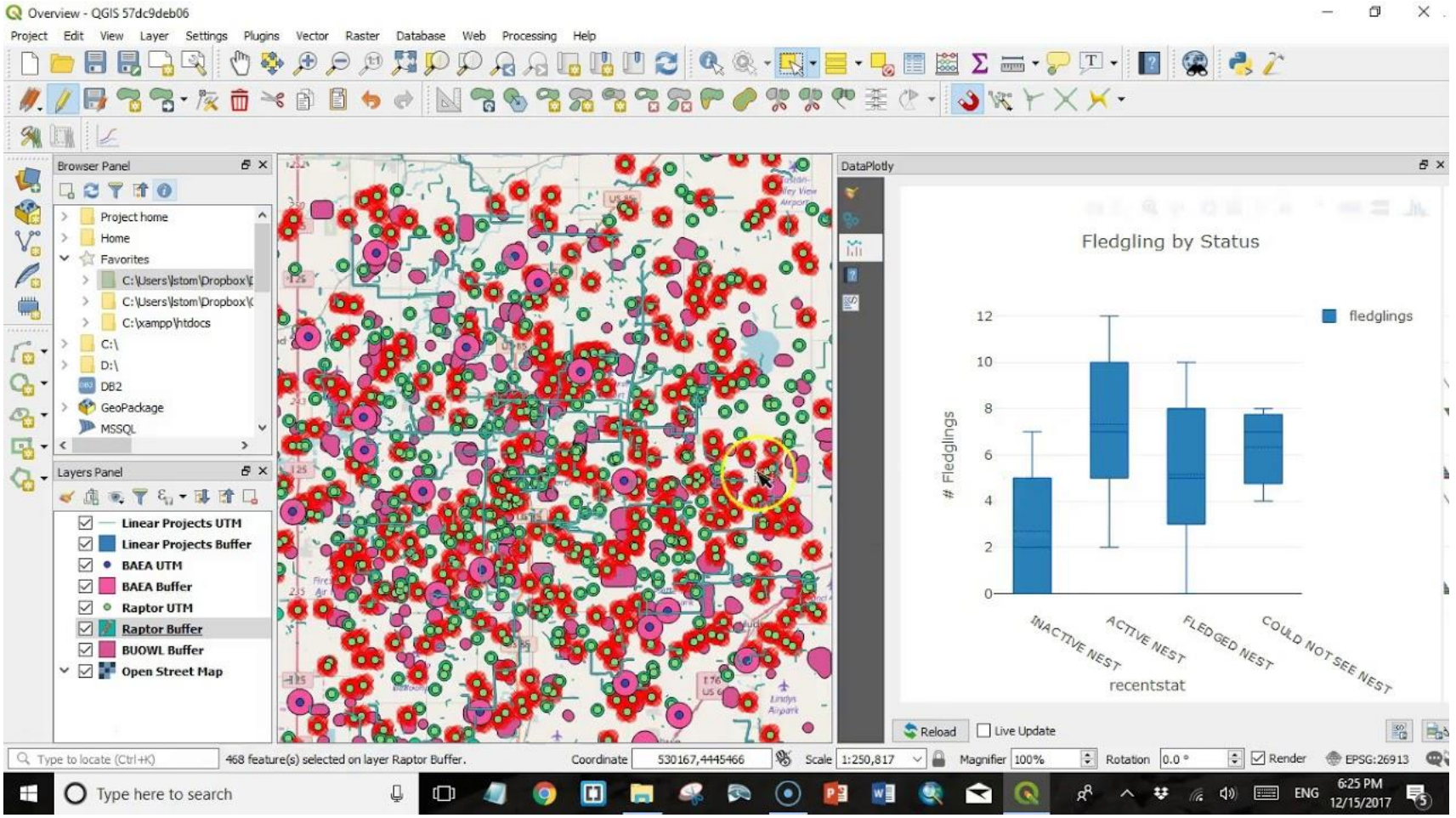
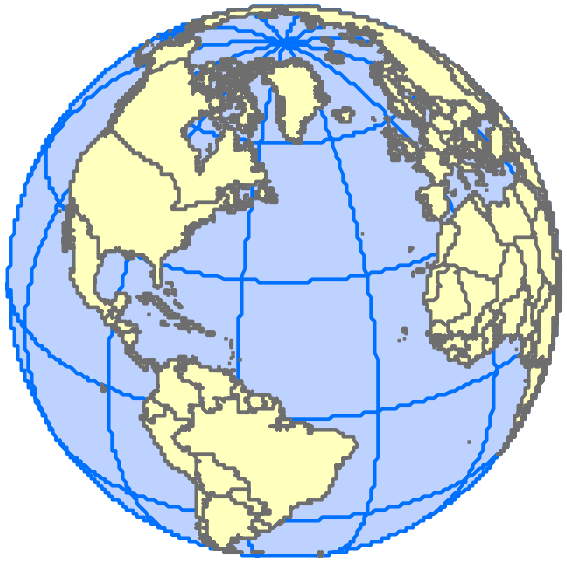
Learning Outcomes

- Under standing of geographical information
- To Known about spatial data modelling
- What is visual image interpretation ?

Lecture II
Introduction to GIS



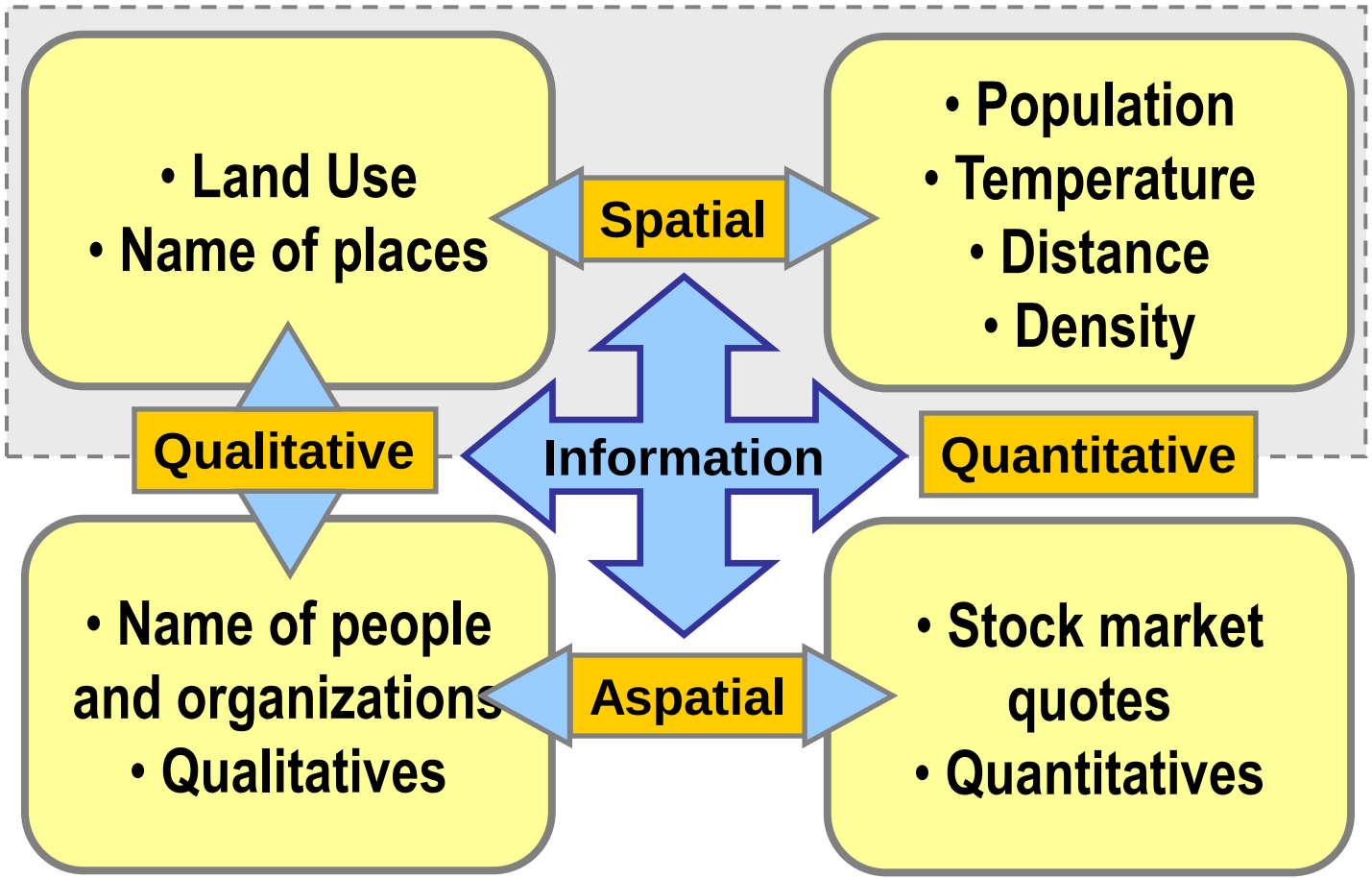
What is Geographical Information?



- Spatial information
  - Between 70 and 80% of the digital information is spatially related.
  - Can be placed on a map.
  - Tools to deal with this information are consequently very useful.
  - Reveal information that was previously “hidden”.

Destination
Customer addresses
Store / factory / warehouse location
Census information
Environmental information
Resource location

A Taxonomy of Information



What is a GIS? Cond…

Geographic Information System

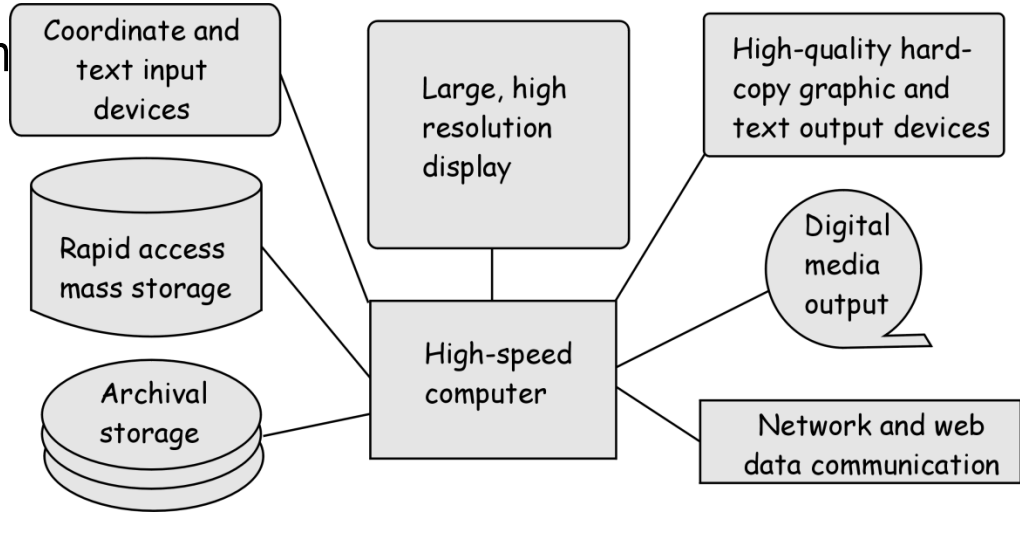
Information system specializing in the input, storage, manipulation, analysis and reporting of geographical (spatially related) information

Encoding — Digitizing maps Encoding spatial data (census, vegetation, topography, etc…)

Management — Geographic database in a spatial data form

Analysis — Spatial analysis

Reporting — Thematic maps



What is a GIS? Cond…….

Data entry
- manual coordinate capture
- attribute capture
- digital coordinate capture
- data import

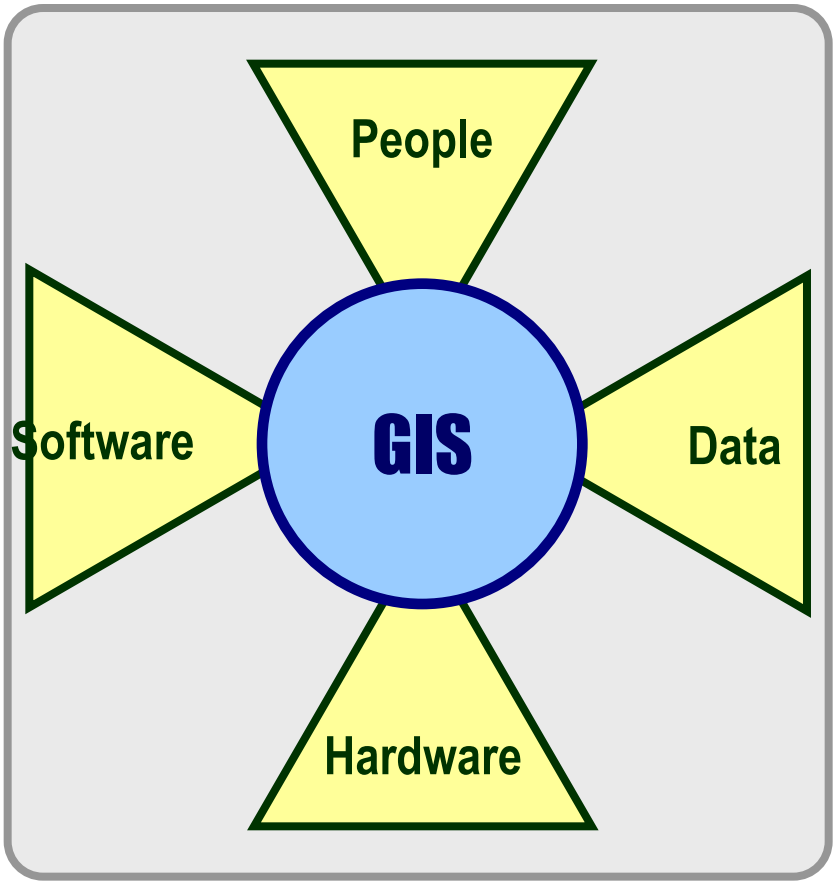
Editing
- manual point, line and area feature editing
- manual attribute editing
- automated error detection and editing

Data management
- copy, subset, merge data
- versioning
- data registration and projection
- summarization, data reduction
- documentation

Analysis
- spatial query
- attribute query
- interpolation
- connectivity
- proximity and adjacency
- buffering
- terrain analyses
- boundary dissolve
- spatial data overlay
- moving window analyses
- map algebra

Output
- map design and layout
- hardcopy map printing
- digital graphic production
- export format generation
- metadata output
- digital map serving

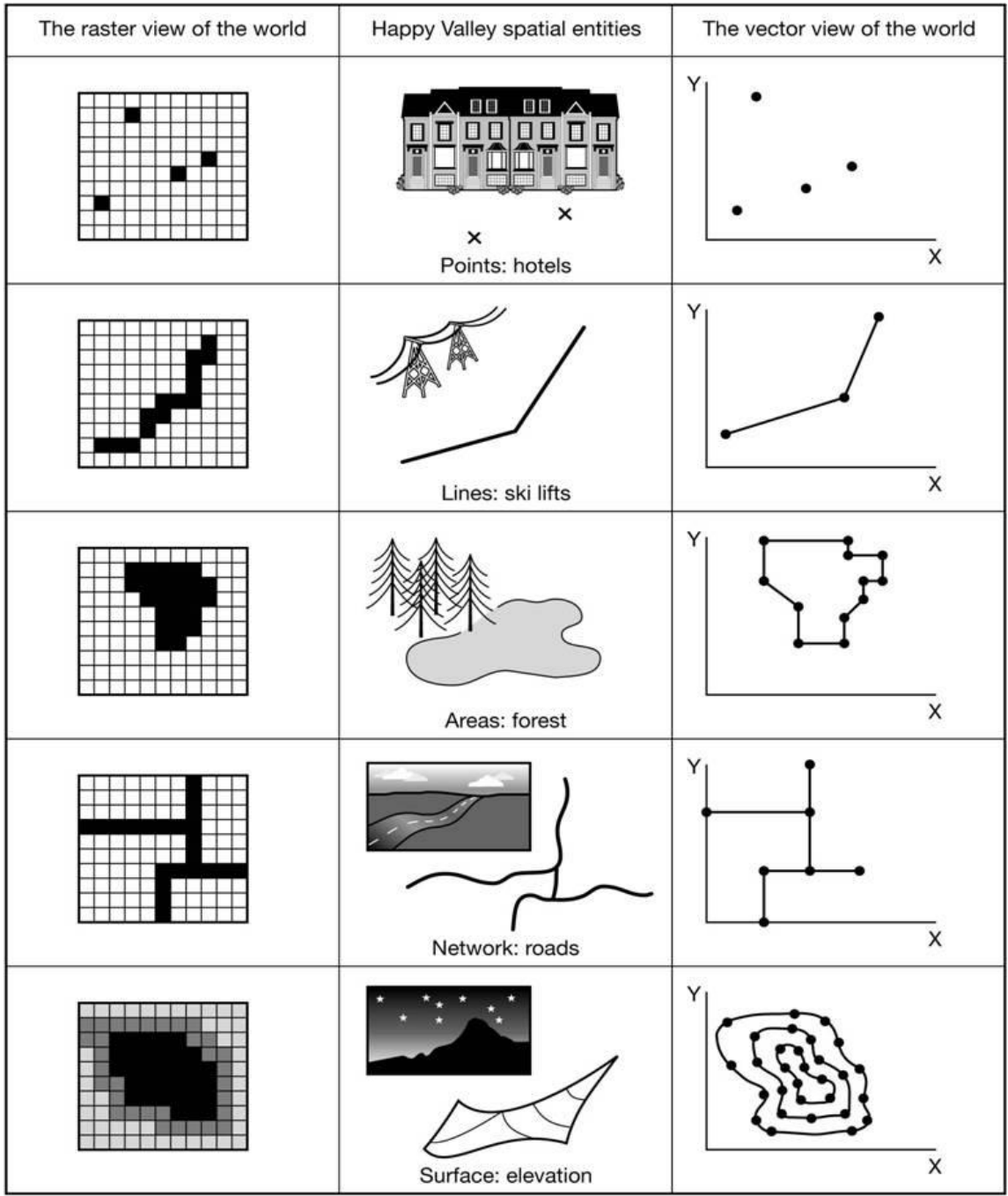
Components of GIS



- People
  - Map user: end consumer.
  - Cartographer: producer of the end product of a GIS.
  - Analyst: applies methods to solve geographical problems.
  - Database administrator: build, update and administer databases.
- Data
  - Remote sensing images or aerial photographs.
  - Topographic maps.
  - Land records. Etc.

Lecture II

Type of Spatial Data



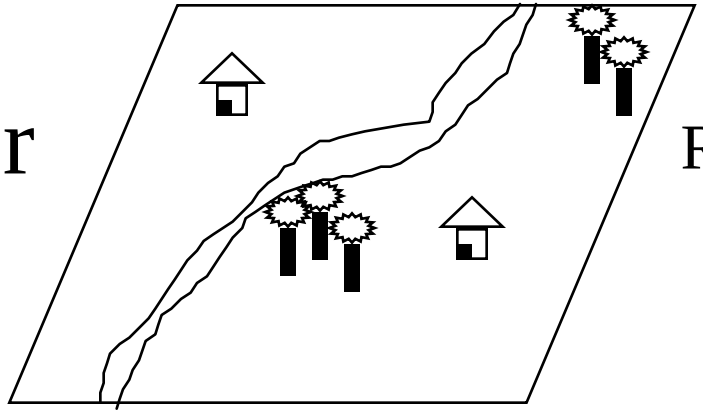
GIS Data Models:
Raster v. Vector

"*raster is faster but vector is corrector*" Joseph Berry

- **Raster data model**
  - location is referenced by a grid cell in a rectangular array (matrix)
  - attribute is represented as a single value for that cell
  - much data comes in this form
    - images from remote sensing (LANDSAT, SPOT)
    - scanned maps
    - elevation data from USGS
  - best for continuous features:
    - elevation
    - temperature
    - soil type
    - land use

- **Vector data model**
  - location referenced by x,y coordinates, which can be linked to form lines and polygons
  - attributes referenced through unique ID number to tables
  - much data comes in this form
    - DIME and TIGER files from US Census
    - DLG from USGS for streams, roads, etc
    - census data (tabular)
  - best for features with discrete boundaries
    - property lines
    - political boundaries
    - transportation

Concept of Vector and Raster

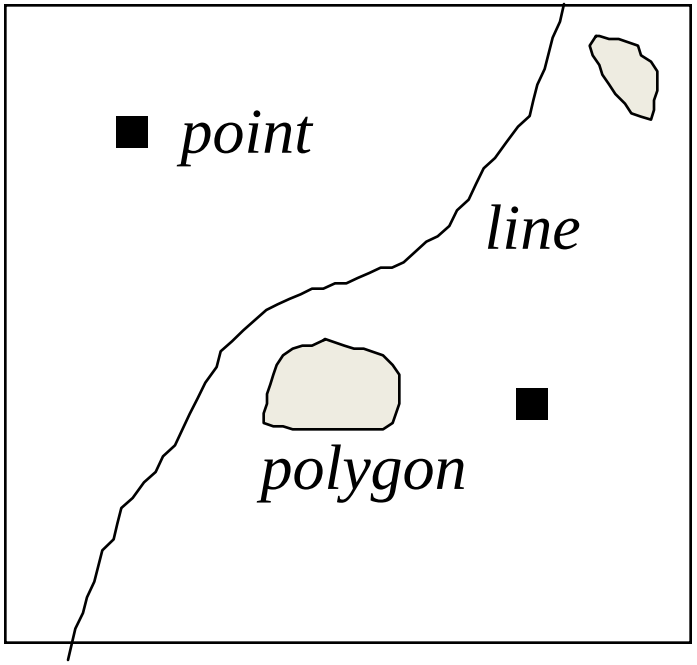


Real World

Raster Representation

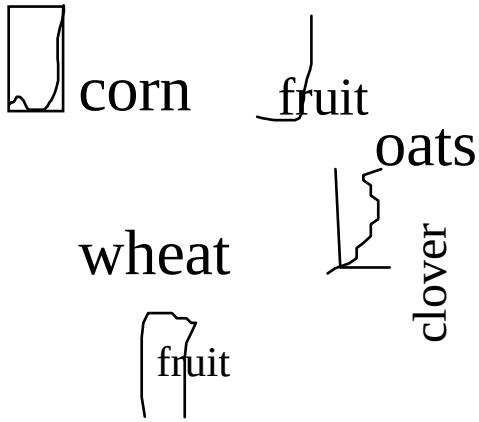
	0	1	2	3	4	5	6	7	8	9
0								R	T	
1							R			T
2		H					R			
3							R			
4					R	R				
5				R						
6			R		T	T		H		
7			R		T	T				
8		R								
9		R								

Vector Representation



Representing Data using *Raster* Model

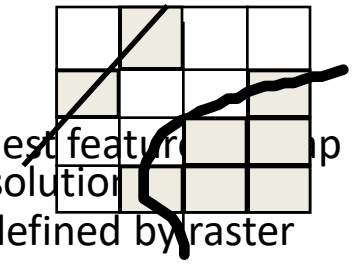
- area is covered by grid with (usually) equal-sized cells
- location of each cell calculated from origin of grid:
  - "two down, three over"
- cells often called *pixels* (picture elements); raster data often called *image* data
- attributes are recorded by assigning each cell a single value based on the majority feature (attribute) in the cell, such as land use type.
- easy to do overlays/analyses, just by 'combining' corresponding cell values: "*yield= rainfall + fertilizer*" (why raster is faster, at least for some things)
- simple data structure:
  - directly store each layer as a single table (basically, each is analagous to a "spreadsheet")
  - computer data base management system not required (although many raster GIS systems incorporate them)



	0	1	2	3	4	5	6	7	8	9
0	1	1	1	1	1	4	4	5	5	5
1	1	1	1	1	1	4	4	5	5	5
2	1	1	1	1	1	4	4	5	5	5
3	1	1	1	1	1	4	4	5	5	5
4	1	1	1	1	1	4	4	5	5	5
5	2	2	2	2	2	2	2	3	3	3
6	2	2	2	2	2	2	2	3	3	3
7	2	2	2	2	2	2	2	3	3	3
8	2	2	4	4	2	2	2	3	3	3
9	2	2	4	4	2	2	2	3	3	3

Raster Data Structures: *Concepts*

- grid often has its origin in the upper left but note:
  - State Plane and UTM, lower left
  - lat/long & cartesian, center
- single values associated with each cell
  - typically 8 bits assigned to values therefore 256 possible values (0-255)
- rules needed to assign value to cell if object does not cover entire cell
  - majority of the area (for continuous coverage feature)
  - value at cell center
  - 'touches' cell (for linear feature such as road)
  - weighting to ensure rare features represented

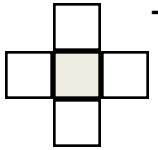


- choose raster cell size 1/2 the length (1/4 the area) of smallest feature on map (smallest feature called minimum mapping unit or resel--**res**olution)
- *raster orientation*: angle between true north and direction defined by raster columns
- *class:* set of cells with same value (e.g. type=sandy soil)
- *zone:* set of *contiguous* cells with same value
- *neighborhood:* set of cells adjacent to a target cell in some systematic manner

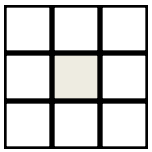
Raster Data Structures: *Tesselations*

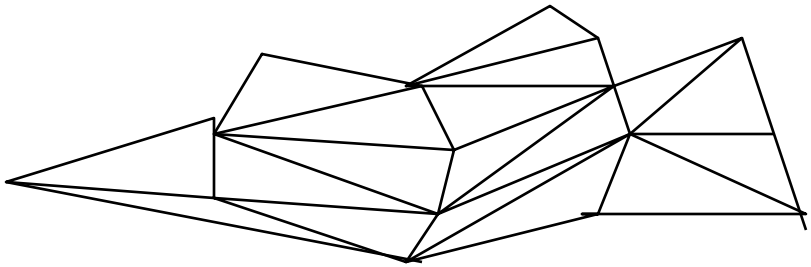
*(*Geometrical arrangements that completely cover a surface.)

- **Square grid**: equal length sides
  - conceptually simplest
  - cells can be recursively divided into cells of same shape
  - 4-connected neighborhood (above, below, left, right) (*rook's case*)
    - all neighboring cells are equidistant

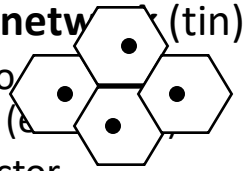


  - 8-connected neighborhood (also include diagonals) (*queen's case*)
    - all neighboring cells **not** equidistant
    - center of cells on diagonal is 1.41 units away (square root of 2)





- **rectangular**
  - commonly occurs for lat/long when projected
  - data collected at 1degree by 1 degree will be varying sized rectangles
- **triangular** (3-sided) and **hexagonal** (6-sided)
  - **all** adjacent cells and points are equidistant



- **triangulated irregular netw** (tin):
  - *vector* model used to continuous surfaces (e
  - more later under vector

Raster Data Structures

Runlength Compression (for single layer)

Full Matrix--162 bytes

1111111222222223
1111111222222233
1111111222222333
1111111222223333
1111133333333333
1111133333333333
1111133333333333
1113333333333333
1113333333333333

Run Length (row)--44 bytes

1,7,2,17,3,18
1,7,2,16,3,18
1,7,2,15,3,18
1,6,2,14,3,18
1,5,3,18
1,5,3,18
1,5,3,18
1,3,3,18
1,3,3,18

This is a "*lossless*" compression, as opposed to "*lossy,*" since the original data can be exactly reproduced.

Now, GIS packages generally rely on commercial compression routines. **Pkzip** is the most common, general purpose routine. **MrSid** (from Lizard Technology)and **ECW** (from ER Mapper) are used for images. All these essentially use the same concept. Occasionally, data is still delivered to you in run-length compression, especially in remote sensing applications.

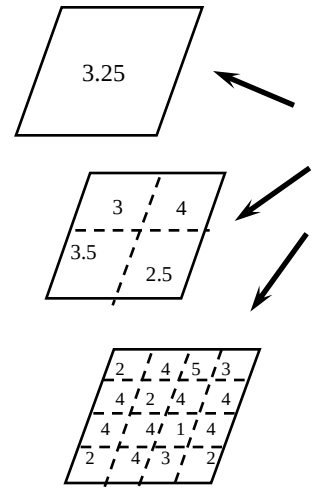
"Value thru column" coding. 1st number is value, 2nd is last column with that value.

Raster Data Structures

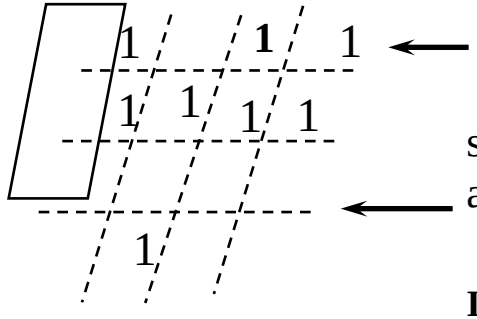
Quad Tree Representation (for single layer)

Essentially involves compression applied to both row and column.

- sides of square grid divided evenly on a recursive basis
  - length decreases by half
  - # of areas increases fourfold
  - area decreases by one fourth
- *Resample* by combining (e.g. average) the four cell values
  - although storage increases if save all samples, can save processing costs if some operations don't need high resolution
- for nominal or binary data can save storage by using *maximum block representation*
  - all blocks with same value at any one level in tree can be stored as single value



Layer	Width	Cell Count
1	1	1
2	2	4
3	4	16
4	8	64
5	16	256
6	32	1024



store this quadrant as single 1

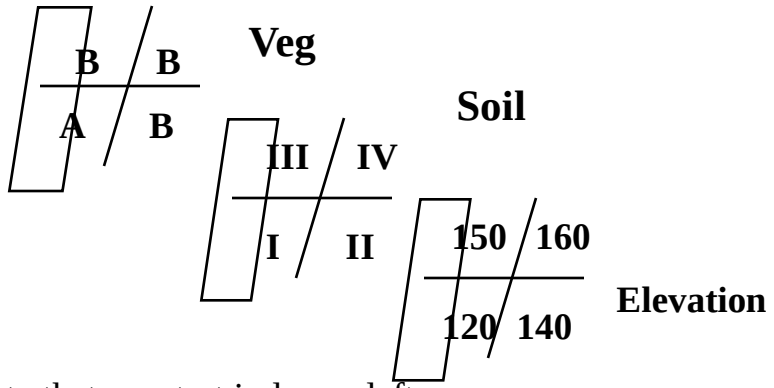
store this quadrant as single zero

I 1,0,1,1 II 1
III 0,0,0,1 IV 0

Raster Data Structures:

Raster Array Representations for multiple layers

- raster data comprises rows and columns, by one or more characteristics or arrays
  - elevation, rainfall, & temperature; or multiple spectral channels (bands) for remote sensed data
  - how organise into a one dimensional data stream for computer storage & processing?
- Band Sequential (BSQ)
  - each characteristic in a separate file
  - elevation file, temperature file, etc.
  - good for compression
  - good if focus on one characteristic
  - bad if focus on one area
- Band Interleaved by Pixel (BIP)
  - all measurements for a pixel grouped together
  - good if focus on multiple characteristics of geographical area
  - bad if want to remove or add a layer
- Band Interleaved by Line (BIL)
  - rows follow each other for each characteristic



Note that we start in lower left.
Upper left is alternative.

File 1: Veg A,B,B,B
File 2: Soil I,II,III,IV
File 3: El. 120,140,150,160

A,I,120, B,II,140 B,III,150 B,IV,160

A,B,I,II,120,140 B,B,III,IV,150,160

Raster Data Structures

Database Representation

- raw data may come in BSQ, BIP, BIL but not good for efficient for GIS processing
- Can be represented as standard data base table
- joins based on ID as the key field can be used to relate variables in different tables

ID	Row	Col	Var1	Var2	Var3
1	1	1	b	III	150
2	2	1	a	I	120
3	1	2	b	IV	160
4	2	2	b	II	140

File Formats for Raster Spatial Data

The generic raster data model is actually implemented in several different computer file formats:

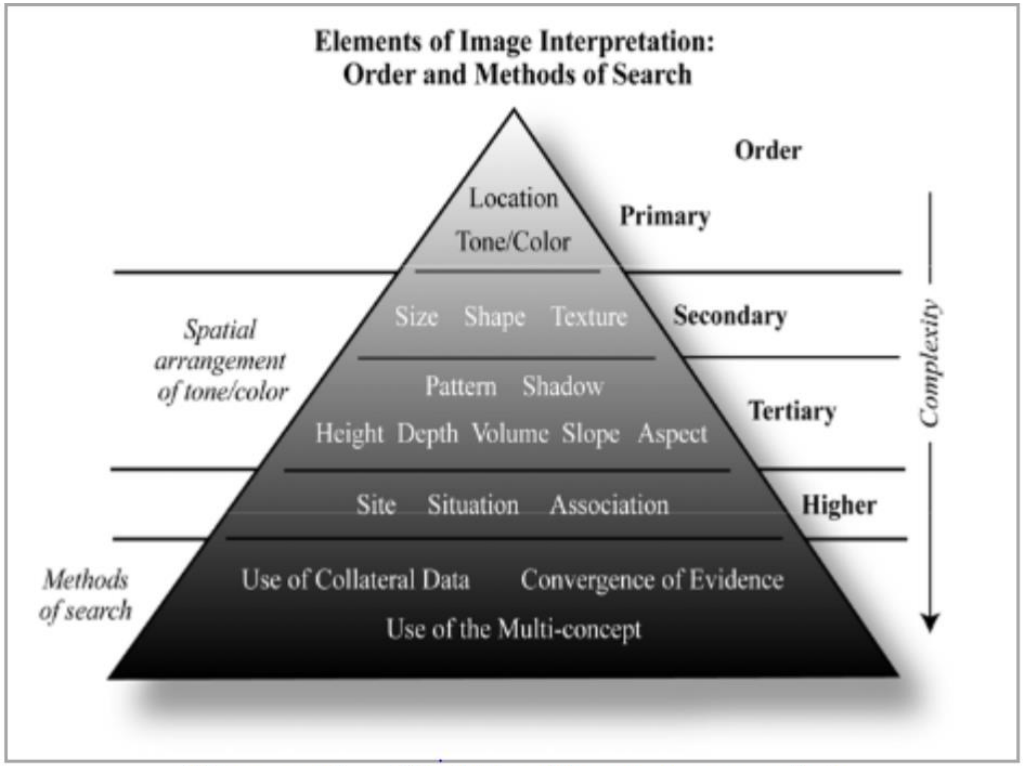
- **GRID** is ESRI's proprietary format for storing and processing raster data
- Standard industry formats for image data such as **JPEG, TIFF** and **MrSid** formats can be used to display raster data, but not for analysis (must convert to GRID)
- *Georeferencing* information required to display images with mapped vector data (will be discussed later in course)
  - Requires an accompanying "world" file which provides locational information

Image	*I*	*mage File*	*World File*
TIFF		image.tif	image.tfw
Bitmap		image.bmp	image.bpw
BIL		image.bil	image.blw
JPEG		image.jpg	image.jpw

Although not commonly encountered, a "geotiff" is a single file which incorporates both the image and the "world" information is a single file.

Lecture III
Visual Image Interpretation

Image interpretation is a powerful technique enable us to identify and distinguish various features in remote sensing images/Aerial photos and allows gaining the knowledge and information about them.



(Image Credit: http://gers.uprm.edu)

Elements of image interpretation

- Image analysis requires explicit recognition of eight ***elements of image interpretation*** that form the framework and understanding of an image
  - Shape
  - Size
  - Tone
  - Texture
  - Shadow
  - Site
  - Association
  - pattern

Shape

- The outline of a feature
  - Important to note that shape depends on perspective
  - Overhead perspective, introduces scale effect

Size

- The first to the dimensions of a feature
- ***Relative size*** determined by comparing the object with familiar nearby features
- ***Absolute size*** refers to the use of the aerial image to derive measurements

Tone

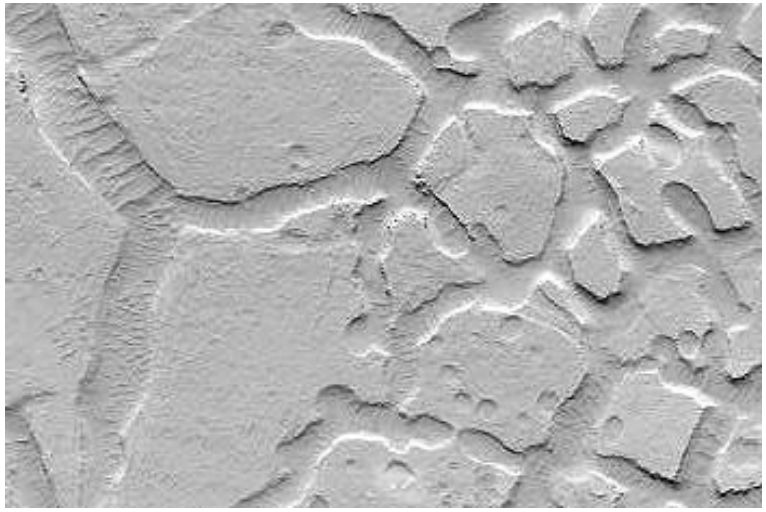
- Refers to the average brightness of an area or, in the case of color imagery, to the dominant color of the region
  - Depends on the nature of the surface in the ankles of observation and illumination.
  - Smooth surfaces behave like ***specular reflectors***, they tend to reflect radiation in a single direction
    - These features may appear bright or dark
  - Rough surfaces behave this ***diffuse reflectors***.
    - Scatter radiation in all directions.
    - A peer is medium gray tones

Texture

- Refers to the variation in tone over a surface or the apparent roughness of the surface as seen in the photo
- Created by micro shadows in small irregularities in the surface.

Shadow

- Refers to large distinctive shadows that revealed the outline of a future as projected onto a flat surface.
  - Depends on the nature of the object, angle of illumination, perspective, and slope of the ground surface



Site

- Refers to a futures position with respect to topography and drainage.
  - Some things occupy a distinctive topographic position because of their function
    - Sewage treatment facilities at the lowest feasible topographic position.
    - Power plants located adjacent to water for cooling

Association

- Association refers to the distinctive spatial interrelationships between features
  - Schools often associated with athletic fields.
  - Large parking lots often associated with malls

Pattern

- Refers to distinctive arrangement of features
  - Orchards have trees plant can rows
  - Mobile home parks have rectangular buildings arranged in rows

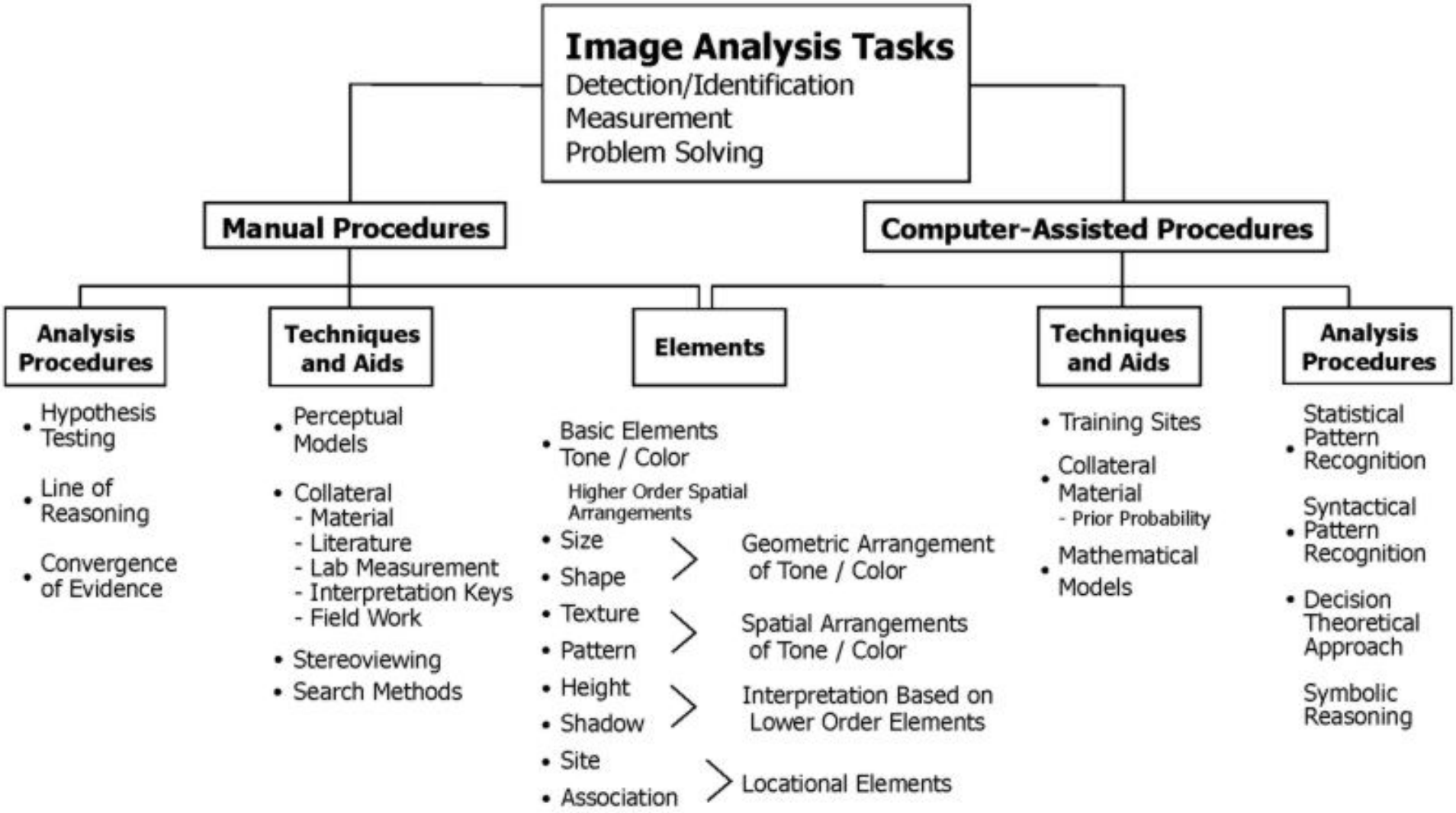


Image Analysis Tasks
Detection/Identification
Measurement
Problem Solving
Manual Procedures
Computer-Assisted Procedures
Analysis Procedures
Hypothesis Testing
Line of Reasoning
Convergence of Evidence
Techniques and Aids
Perceptual Models
Collateral
- Material
- Literature
- Lab Measurement
- Interpretation Keys
- Field Work
Stereoviewing
Search Methods
Elements
Basic Elements
Tone / Color
Higher Order Spatial Arrangements
Size
Shape
Geometric Arrangement of Tone / Color
Texture
Pattern
Spatial Arrangements of Tone / Color
Height
Shadow
Interpretation Based on Lower Order Elements
Site
Association
Locational Elements
Techniques and Aids
Training Sites
Collateral Material
- Prior Probability
Mathematical Models
Analysis Procedures
Statistical Pattern Recognition
Syntactical Pattern Recognition
Decision Theoretical Approach
Symbolic Reasoning

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