GI 10
econd eme ter Te t

April

Que tion 1

- Name and di cu the different mode of data input in a GI . Al o refer to the quality of data et that can be obtained from each method and give example of when it will be appropriate to u e each input method.( )

Modes of data input

1. Keyboard entry for non- patial attribute and occa ionally locational data (hould be of high quality – can check data)
2. Manual locating device
   - u er directly manipulate a device who e location i recognized by the computer
   Quality Depend on per on digiti ing and quality and cale of document
   - e.g. digitizing, computer mou e
3. Automated device
   - automatically extract patial data from map and photography
   -e.g. canning Quality depend on canne and ource document
4. Conver ion directly from other digital ource (Depend on data tream

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Keyboard Entry

- Keyboard entry of coordinate data
- e.g., point lat/long coordinate
  - from a gazetteer (a li ting of place name and their coordinate)
  - from location recorded on a map

Latitude/Longitude coordinate conversion

- Latitude i y-coo, longitude i x-coo!
- Common format i
  degree , minute , econd
  11 1 ' W 6 07" N
- To repre ent lat/long in a GI , we need to convert to decimal degree
  -11 .
- DD = D + (M + / 60) / 60

Manual locating devices: Digitisers

Digiti er are the mo t common device for extracting patial information from map and photograph

- The map, photo, or other document i placed on the flat urface of the digiti ing tablet

The digitising operation

The map i affixed to a digiti ing table

Three or more control point ("reference point ", "tic ", etc.) are digiti ed for each map heet

- the e will be ea ily identified point (inter ection of major treet , major peak , point on coa tline)
- the coordinate of the e point will be known in the coordinate y tem to be u ed in the final databa e, e.g. lat/long, tate Plane Coordinate , military grid
- the control point are u ed by the y tem to calculate the nece ary mathematical tran formation to convert all coordinate to the final y tem

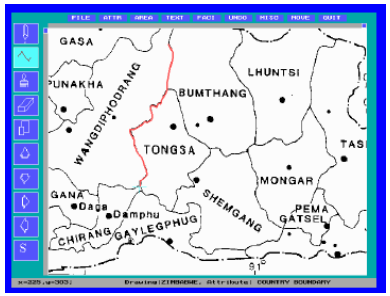
Digitising Steps

- The trace feature to be digiti ed with pointing device (cur or), u ing either:-

1. point mode: click at po ition where direction change
2. tream mode: digiti er automatically record po ition at regular interval or when cur or moved a fixed di tance

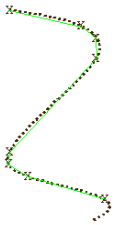
Heads-UP Digitising

- Ra ter- canned image on computer creen
- Operator follow line on- creen in vector mode



How Much to Input- Vector Data

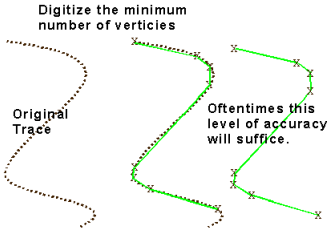
- Digiti e vector at a level needed for your objective or purpo e.



e the minimum number po ible.

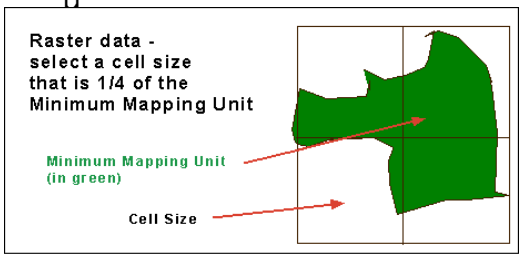
How Much to Input- Vector Data

- Here the **X** i a digiti ed point taken with **"point mode"** where in tead one could have u ed **"stream mode"** and captured all the point repre ented by the dot , at a high co t in effort and torage without adding to the accuracy.



How Much to Input- Raster Data

- Ra ter - elect a cell ize 1/4 the ize of the Minimum Mapping nit



Problems with digitising maps

Ari e ince mo t map were not drafted for the purpo e of digiti ing

- paper map are un table: each time the map i removed from the digiti ing table, the reference point mu t be re-entered when the map i affixed to the table again
- if the map ha tretched or hrunk in the interim, the newly digiti ed point will be lightly off in their location when compared to previou ly digiti ed point
- error occur on the e map , and the e error are entered into the GI databa e a well
- the level of error in the GI databa e i directly related to the error level of the ource map

Problems with digitising maps

Map are meant to di play information, and do not alway accurately record locational information

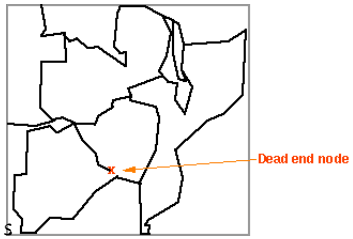
- For example, when a railroad, tream and road all go through a narrow mountain pa , the pa may actually be depicted wider than it actual ize to allow for the three ymbol to be drafted in the pa

Di crepancie acro map heet boundarie can cau e di crepancie in the total GI databa e

- e.g. road or tream that do not meet exactly when two map heet are placed next to each other

Problems with digitising maps

er error cau e over hoot , under hoot (gap) and pike at inter ection of line

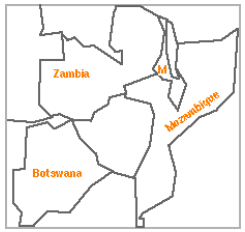


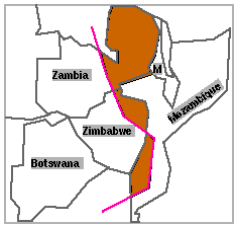
er fatigue and boredom

Editing errors from digitising

ome error can be corrected automatically

Error rate depend on the complexity of the map, are high for mall cale, complex map





Advantages and disadvantages of manual digitising

- Advantage :
  1. can be performed on inexpen ive equipment,
  2. require little training,
  3. doe not need particularly high map quality.
- Di advantage
  1. tediou ,
  2. time con uming.

Automated devices: Scanning

- canner are u ed in GI to input map and photo information
- Quality of thi information i related to the quality of the canner and the quality of the ba e map being canned
- canner = quick olution to data input B T...
- Following the canning proce , the map i tored in a ra ter format with pixel repre enting the location of feature

Requirements for scanning

- Document mu t be clean (no mudge or extra marking)
- Line hould be at lea t 0.1 mm wide
- Complex line work provide greater chance of error in canning
- Text may be accidentally canned a line feature
- Contour line cannot be broken with text
- Automatic feature recognition i not ea y (two contour line v . road ymbol) diagram
- pecial ymbol (e.g. mar h ymbol) mu t be recognized and dealt with
- If good ource document are available, canning can be an efficient time aving mode of data input

Scanning

- canner output i a ra ter data et
- ually need to be converted into a vector repre entation
  - manually (on- creen digiti ing)
  - automated (ra ter-vector conver ion)
    - line-tracing - e.g., Map can
- Often require con iderable editing

Advantages and disadvantages of scanning

- Advantage :
  1. ea ily performed,
  2. rapid.
- Di advantage
  1. require expen ive equipment, (can make u e of peciali ed companie)
  2. involve expert per onnel,
  3. u ually entail con iderable editing,
  4. need clean map with well defined line ,
  5. produce large quantitie of data,

Electronic data transfer

Tran ferring of digital data from one format to another

er mu t a k the following que tion if they wi h to obtain data in digital form from another ource

1. What data are available
   - GI data clearinghou e
2. What will the data co t
   - Varie depending on the agency, company

Electronic data transfer

3. On what media will the data be upplied
   - Magnetic media, optical di k , network tran fer , Internet
4. What format will the data be in – will tandard be adhered to
   - A yet there i NO agreed international . tandard on metadata for geographical information.
   - A a re ult increa ing number of GI vendor with compatibility for a wide array of data format

Que tion

Define and explain what the lineage of a data et i .

Al o refer to the benefit of lineage.(1)

Lineage

- Lineage is a record of data history which is presented as a descent or ancestry

FAMILY  TREE

- Lineage lets the user know where problems with the data are likely to occur
- Lineage information can be recorded manually or automatically

Lineage

- Basic lineage requirements:-

1. Describe the source of data
   - Information including the name, date, method of production, date of last modification, producer, reference, map scale, and projection

2. Transformation documentation
   - Includes details of the data files used and the products generated

Lineage

3. Input/output specifications
   - Includes descriptions of file formats, transfer formats, input/output procedures, media specifications etc

4. Application-dependent information
   - Record information about the purpose for which a particular data set was generated
     - Helps the user determine for which applications the data are useful

Lineage

- Benefits of lineage:-

A. Error detection
   - Lineage helps recreate analysis processes in which previous data sets containing errors have been used

B. Management accountability
   - Lineage provides information from which accounting can be undertaken

Lineage

C. External accountability

- Lineage records the work of each GIS user
- Allows the assessment of the validity of the work undertaken

D. Quality reporting

- Lineage is required for GIS data quality reports
- Include information on data history, positional accuracy, attribute accuracy and completeness

Que tion

Define and di cu any of the following correcting method :

Reprojection ( )

Tran formation ( )

Generali ation ( )

Edge-matching ( )

Rubber- heeting ( )

1

Re-projection

• Data derived from maps drawn on different projections will need to be converted to a common projection system before they can be combined or analysed

• Data derived from different data sources may also be referenced using different co-ordinate systems

Transformation

- Data from variety of sources are only useful if in the same map projection
- Most GIS software provide functions for transformations
- Transformations are based on fixed mathematical relationships that describes the various projections
- Transformation converts the coordinates of one system to the coordinates of another

Transformation

- Methods used:-

1. Translation and scaling

 - One data set may be referenced in 1-metre co-ordinates while another is referenced in 10-metre co-ordinates. If a common grid system of 1-metre co-ordinates is required, then simply multiply the co-ordinates in the 10-metre data set by a factor of 10

Transformation

2. Creating a common origin

 - If two datasets use the same co-ordinate resolution but do not share the same origin, then the origin of one of the data sets may be shifted in line with the other simply by adding the difference between the two origins (d*x*, d*y*) to its co-ordinates

3. Rotation

 - Map co-ordinates may be rotated using simple trigonometry to fit one or more datasets onto a grid of common orientation

Generalisation

- Generalisation is a group of techniques that allow the amount of information to be retained even when the amount of data is reduced

 - e.g. when the number of points on a line are reduced, the points to be retained are chosen so that the line does not change its appearance

- In some cases generalisation actually causes an increase in the amount of information

 - e.g. generalisation of a line representing a coastline is done best when knowledge of what a coastline should look like is used

Generalisation

1. Simplification
 - simplification algorithms weed from the line redundant or unnecessary coordinate pairs based on some geometric criterion

2. Smoothing
 - smoothing routines relocate or shift coordinate pairs in an attempt to "plane" away small perturbations and capture only the more significant trends of the line

Generalisation

3. Feature displacement

   - displacement involves the shifting of two features at a reduced scale to prevent coalescence or overlap

4. Enhancement/Texturing

   - enhancement allows detail to be regenerated into an already simplified data set

   - e.g. a smooth curve may not look like a coastline so the line will be randomly textured to improve its appearance

Justification for generalisation

A. Reduced plotting time

- plotting time is often a bottleneck in many GISs
- as the number of coordinate pairs is reduced through the simplification process, the plotting speed is increased

B. Reduced storage

- coordinate pairs are the bulk of data in many GISs
- simplification may reduce a data set by 70% without changing the perceptual characteristics of the line
- this results in significant savings in memory

Generalisation – vector data

• Data may be derived from maps of different scales

- if widely differing scales are to be used together,
- data derived from large-scale mapping should be
- generalised to be comparable with data from small-scale

• Routines exist in most vector GIS packages for weeding out unnecessary points from digitised lines

• Simplest techniques delete points along a line at a fixed interval (e.g. every third point)

ALWAYS KEEP A COPY OF THE ORIGINAL

Generalisation – raster data

• Most common method to generalise raster data is to aggregate or amalgamate cells with the same attribute value

• Loss of detail = severe

• Another option = using filtering algorithm

• If main motivation for generalisation is to save storage space then better to use appropriate data compaction technique

ALWAYS KEEP A COPY OF THE ORIGINAL

Edge-matching

- **Definition of edge matching :**

The GI or digital map equivalent of matching paper map along their edge . Feature that continue over the edge must be "zipped" together, and the edge dissolved. To edge match, map must be on the same projection, datum, ellipsoid, and scale, and how feature captured at the same equivalent scale

Edge-matching

1. Mismatches at sheet boundaries must be resolved

   - Lines and polygons boundaries must be joined together to complete features and ensure topologically correct data
   - Serious problems: CLASSIFICATION

   Soil surveyor Satellite imagery

2. Topology must be rebuilt as new lines and polygons have been created from the segments that lie across map sheets

Edge-matching

- Two source of complication exist when two adjoining coverage are edge matched:-
  1. Two map that were entered with the same projection but since they were inserted separately are inclined to exhibit entity error that are rather dissimilar
  2. Difficulties arise during edge matching when two adjoining coverage are entered from different projection

Rubber-sheeting

- Internal distortions exist within map sheets – especially true for data derived from aerial photography. WHY??
- Distortions remain even after transformation and re-projection
- Rectified through a process known as rubber-sheeting

Rubber-sheeting

- Involves stretching the map in various directions as if it was drawn on a rubber sheet
- Objects accurately placed on the map are 'tacked down' and kept while others in 'wrong' location are stretched to fit on the control points
- Control points are fixed features identified on the ground and on the image

Rubber-sheeting

- Rubber-sheeting a base map to fit new co-ordinates
  - the most common rubber sheeting need is to make an existing basemap conform to a new set of calibration data
  - used to make an existing map more accurate
  - requires as many calibration points as possible and the coordinates should be as accurate as possible

Rubber-sheeting - problems

- Lack of suitable control points – the position of which have to be determined using GPS readings
- High processing time required for large and complex data sets
- With too few control points the process of rubber- sheeting is insufficiently controlled over much of the map sheet = unrealistic distortion

Que tion

In both a ra ter and vector GI there exi t variou method that can be u ed for the analy i of data. Di cu the following analy i method in term of definition , different type (if applicable) and u age. Choo e your own application field and explain how the analy i method can be applied to an wer complex patial que tion

Mea urement of di tance and area ( )
Attribute querie (1)
patial Querie (10)
Buffering and neighbourhood function (10)
Overlay (10)

(0)

Calculating distance

- Common application in GI environment
- How doe GI go about calculating di tance
- Vector v . Ra ter
- Important to rem mber that all mea urement in GI will be approx mation . Why

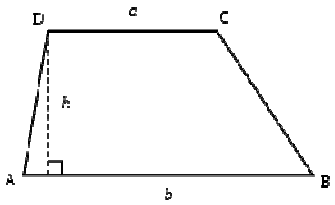
Vector GIS

- e co-ordinate value of tart and end point to work out the length of a line
- ector perimeter = line egment + line egment
- Fully topological vector GI will calculate area and perimeter of polygon at the time that topology i created
- Advantage = perimeter and area are tored in a databa e and can be u ed and queried
- Example = population den ity of electoral ward

3

Vector GIS - Area

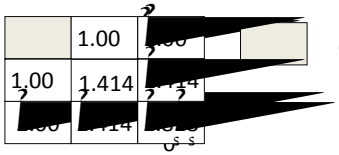
- Mo t frequent method to find area i by con tructing a et of trapezoid
- Work out area of each trapezoid – add together



A figure with two parallel ide i referred to a **trapezoid** in North America, and a a **trapezium** in Great Britain.

Raster GIS

- Berry (199): Alternative to the Pythagorean approach – proximity
- Method: . Concentric equidi tant zone are e tabli hed around the location of intere t



Origin cell

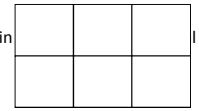
- The di tance to a cell in the next 'ring' of cell i calculated ba ed on information from previou ring
- Either orthogonal or diagonal di tance

3

Raster GIS – perimeter and area

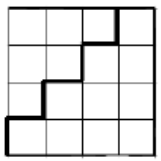
- Perimeter calculation in raster GIS
- Trace around polygon and count up the pixel side
- Multiply: No. of pixel sides * Dimension of pixel

- AREA:
  Multiply: No. of pixel in

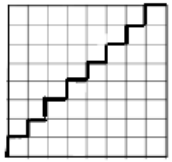


Raster GIS – problems

1. One factor which influences distance, perimeter and area in raster GIS is the **resolution** of the data



large pixel size

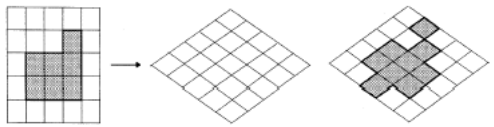


small pixel size

- Although the length is the same under both pixel sizes the precision of the line in the second case is better

Raster GIS – problems

2. Another problem with length, perimeter and area calculation results from the orientation of the raster grid with respect to the polygon of interest



(a) area=7 units — change in grid orientation — (b) new area=9 units

Polygon straight-sided and fit in the pixel pattern

Polygon fallen at an angle to the pixel grid

Overview

- Selection (according to attribute criteria)
  - Set Algebra
  - Boolean Algebra
- Classification
- Dissolve

1. ELECTION

- Identifie feature that meet one to everal condition
- Attribute are checked again t criteria
- An wer u ually hown in a election
- Can be written to a new layer or u ed for further manipulation

On creen querie

- imple t form of election i on creen query
- Layer i di played and feature i elected by the operator
- Operator u e a pointing device to identify the feature.
- ed for once of querie or update/editing of attribute data.

et Algebra

- election condition often formali ed u ing et algebra:
  - =
  - <>
  - <
  - >

  } Cannot be applied on nominal data
- Can be applied alone or in combination to elect feature from a et.

Boolean Algebra

- Boolean Algebra u e the condition :
  - OR
  - AND
  - NOT
- ed to combine et algebra condition to create compound patial election
- re evaluated by a igning an outcome (true or fal e) to each ondition.
- Order of application of boolean operator are important
- Parenthe i () are u ed to pecify order of application

CLA IFICATION

- I very common and often generated in GI analy i
- Often u ed in conjunction with election
- Al o known a recla ification or recoding
- Will categori e feature ba ed on a et of condition
- Cla ification may add to or modify attribute data which may be u ed for further analy i
- Can al o be u ed to group object for di play or map production – imilar object are identified a a group
- Di play colour are a igned ba e on the attribute
- Cla e may be a igned automatically or manually

EXAMPLES:

Cla ification

- Binary Cla ification – imple t form of cla ification
Place object into two cla e – 0 and 1, true or fal e etc.
Often u ed to tore the re ult of complex election operation

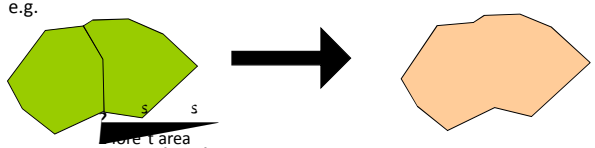
Manual definition may be tediou – rather do it automatically
Automatic cla ification u e ome rule to a ign cla e
A igning of boundarie to cla e may be a problem.
Mathematical calculation or algorithm a ign cla e .
Group may be plit
Time can be aved but we may have to adju t the boundarie manually
The way cla e are a igned will change the appearance of the map

Choo ing a Cla ification Method

- Very often you will define your own cla e rather than making u e of the exi ting cla ification method . The better you know your data et the better you can define the cla e If you are not ure which cla e to u e you mu t con ult a peciali t and find out which cla e to u e in a project. E.g. high traffic volume in ohanne burg will differ from high traffic volume in Delma , high population den ity in KwaZulu Natal will differ from high population den ity in the Kalahari.
- To choo e the correct cla ification method you need to know how the data value are di tributed in a data et:
- If the data are evenly di tributed or there are gap between group of value you will make u e of natural break
- If your data i evenly di tributed and you want to empha i e the difference between the feature you will make u e of equal interval or tandard deviation.
- If your data i evenly di tributed but you want to empha i e the relative difference you will make u e of quantile

Di olve

- Di olve – combining feature ba ed on attribute data
- Adjacent polygon may have the ame value for an attribute
- Are u eful to remove unneeded information
- Very often follow on cla ification (depending on your application)
- Di olve reduce volume ize – increa ed proce ing peed
- May lo e important attribute data when doing di olve function
- ALWAY KEEP A COPY OF THE ORIGINAL
- e.g.



Attribute data
Di olve boundarie

Overview

- patial Data Querie
  - patial v . non- patial querie
  - by cur or
  - by Graphic
  - by patial Relation hip
- Method of patial data enquiry
  - -Containment
  - -Inter ect
  - -Proximity
- Querying a vector GI
- Combining querie - example
- Querying a ra ter GI

patial Data

- When we talk about patial data, we mean data that ha a patial component
- Both patial and non- patial (i.e., de criptive, or al o alphanumeric, attribute) a pect are a ociated with thi kind of data. For example, a river will have attribute information a ociated with it (uch a it name and length) together with it geometric de cription (the patial component)
- Often we talk about patial data to mean it patial component

patial Data Querie

- patial data query i the proce of retrieving data from a map theme (or theme) by working with map feature .
- patial data query i the geographic interface to the attribute databa e and i , therefore, u eful for ta k that cannot be ea ily accompli hed through attribute data query.

1. Selection by Cursor

* imple t method of patial data query.
* elect feature( ) u ing pointing device
  - individual election u ing cur or
  - group election u ing area

2. Feature Selection by Graphic

- elect feature from the active theme that are contained within or are inter ected by a graphic object.
  - line
  - circle
  - box
  - Polygon

E.g.

- ❖ electing re taurant within a one-km radiu of a hotel,
- ❖ electing land parcel that inter ect a propo ed highway

3. Feature Selection by Spatial Relationship

- elect map feature ba ed on their patial relation hip to other feature .
  - a) elect feature in ame theme
    - Find the road ide re t area within a radiu of 0 km of a elected re t area.
  - b) elect feature within another theme
    - Find re t area within a certain county.

Methods of Spatial Data Query

– by patial Relation hip

- Containment
  - elect feature that fall completely within feature u ed for election
  - E.g. finding chool within a elected county
- Inter ect
  - elect feature that inter ect featue u ed for election
  - E.g. electing land parcel that inter ect a propo ed road

Methods of Spatial Data Query

- Proximity
  - elect feature that are within a pecified di tance of feature u ed for election
  - E.g. finding national park within 10 km of an highway, and finding pet hop within one km of elected treet
  - If feature to be elected and feature u ed for election hare common boundarie in a theme and if the pecified di tance i 0, then proximity become ***adjacency***

Querying a vector GIS

• Type of vector GI querie according to Haining (1994)

1. Univariate

a. A patial

De cribe the pH of the oil type
- numerically (e.g. mean, median, etc)
- graphically (normal di tribution, kewed etc.)

b. patial

Map ca e of oil where the pH i higher than the average

Querying a vector GIS

2. Multivariate

a. A patial

De cribe the propertie of the oil and rainfall (e.g. what relation hip exi t between oil pH and rainfall)

b. patial

Where are the ca e with greater than average pH value and high rainfall

Querying a vector GIS

• The ea e with which the e querie can be implemented i a function of the relation hip between the graphic data and the attribute data

• With mo t vector GI a link between the e two data type i et up a topology i created

• I.e. each graphical entity ha unique identifier = reference a databa e table containing the related attribute

Querying a raster GIS

• Querie are generally one of two option :-

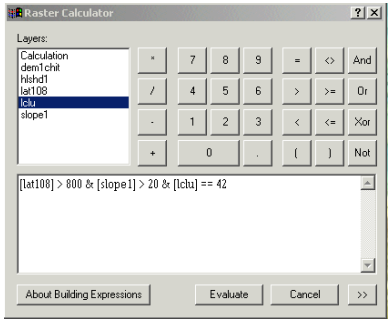
1. What i at ...
2. Where i ...

• For ra ter the equivalent i :-

1. What i the content of a given pixel
2. Which pixel have thi value

Map Query Examples

• Let's say our criteria are elevation >800, slope >20% and land use category= coniferous forest (42)



The role of error

• Map and attribute data error are the data producer's responsibility, but the GIS user must understand error.

• Accuracy and precision of map and attribute data in a GIS affect all other operations, especially when maps are compared across scales.

• Error can propagate as queries and overlays continue through a project

Buffer

- A primary single map layer operation
- Involves the creation of new information
- Has a strong spatial element
- Is most common operation

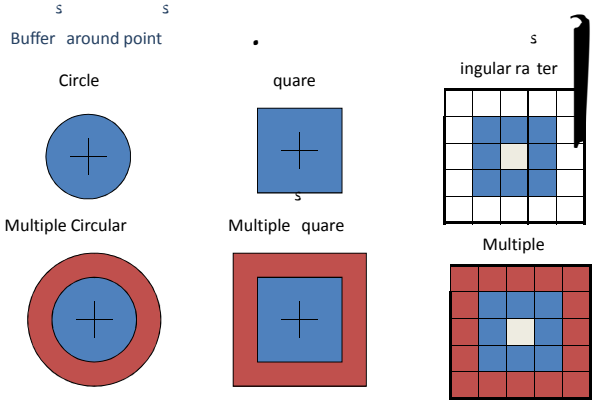
What is a buffer

- **Definition:** A zone of a specified distance around features in a coverage. Buffers can be set at constant or variable distance based on feature attributes. The resulting buffer zones form polygonal coverages. (GIS Lounge – glossary)

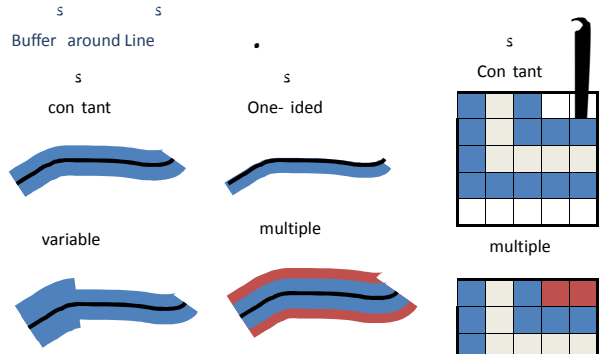
Buffering

- Po ible in both ra ter vector format .
- Di tance calculation are ju t performed differently.
- Other term :
  - pread
  - earch
  - Corridor
  - Zone

What type of buffer are there



What type of buffer are there



Example

- e buffer a part of analy i for iting a radioactive wa te repo itory
- epo itory ha to be away from tran port oute
  - All road = (km)
  - Highway = (1, km)
  - Railway = (0, km)

Rook' ca e v . Queen' ca e (Ra ter GI)

- Buffer allow a pixel or group of pixel to "grow" out in all direction .
- Buffer can be accompli hed two way :
  - the 'rook' ca e' and
  - 'queen' ca e'.

Buffering di tance :

- In tigated on gue work
  - hould the boundary around a con truction ite be 1 m, m or
- Ba ed on prior knowledge about the area within which the buffer i produced.
  - Rate at which water permeate through different oil
- elected on the ba i of a definable, mea urable value.
  - Rate at which noi e di ipate
  - Average di tance people are willing to walk to a bu top.
- Legal or otherwi e mandated mea ure exi t and mu t be adhered to.
  - Flood line
  - Not building within certain di tance of a road.

What hould the buffer di tance be

- Are there any petrol tation **near** my ite
- The ite **close to** the freeway.
- I the ite **far from** the river

The e of everyday language to de cribe di tance.

Overlay

Overlay operation – powerful patial analy i tool . Important driving force behind development in GI

Combining **spatial and attribute** data from two or more patial data layer

E.g.

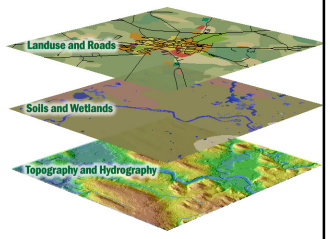
Where are propertie for ale within walking di tance from chool

Where are inkhole on dolomite

Which propertie will be affected by the expan ion of the airport

Data layer mu t u e ame **coordinate system**

May be een a the vertical tacking and merger of patial data and attribute data



1. Ra ter Overlay

- Cell by cell combination of two or more data layer (can be any number of layer)
- Cell value are combined in ome way - output alway in a new layer.
- Typically applied to nominal or ordinal data
- Each value corre pond to pecific category
- Combined u ing a mathematical calculation and map algebra
  - Map Calulator

Map Algebra operator

- Arithmetic operator :
  - +
  - -
  - *
  - /
- Logical operator
  - =
  - >
  - <
  - <> etc.
- Boolean operator
  - AND
  - OR
  - XOR
  - NOT

Overlay u ing weight

- One theme more ignificant than another
- Degree of importance expre ed a weight
- Either recode accordingly
- Or u e weighting factor in overlay proce

Difficultie in ra ter overlay

- Re olution cale of mea urement
  - Data problem
  - Not technical

Vector Overlay

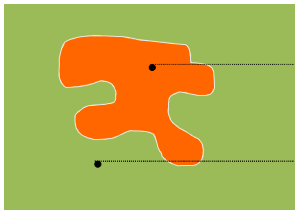
- Involve combining point, line and polygon geometry.
- Overlay can be any combination
(Point-on-point and Point-on -Line inter ection have rarely any re ult)
- Mo t common overlay are Polygon-on-polygon
- Time con uming and computational inten ive proce

Point in Polygon

- In imple t form:
  - Determine whether a given point lie in ide or out ide a polygon
- Can be extended:
  - Many point
  - Many polygon
  - Overlapping polygon

How point in polygon analy i work

- Many method
- imple t
  - 'Plumbline' or ordan method
  - Extend horizontal (or vertical line)
  - Count cro ing
  - ODD → in ide
  - EVEN → out ide



Line in polygon

- ed to determine if a line feature in a polygon feature.
  - What admini trative area a road i in
  - What rock type a river flow over
- Which polygon i thi line *"contained in"*

Line in polygon

- plit line into egment where inter ect with polygon .

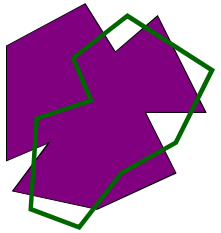
Create new layer and attribute tables

ID	Name
1	N1

ID	Name
11	N1
12	N1
13	N1

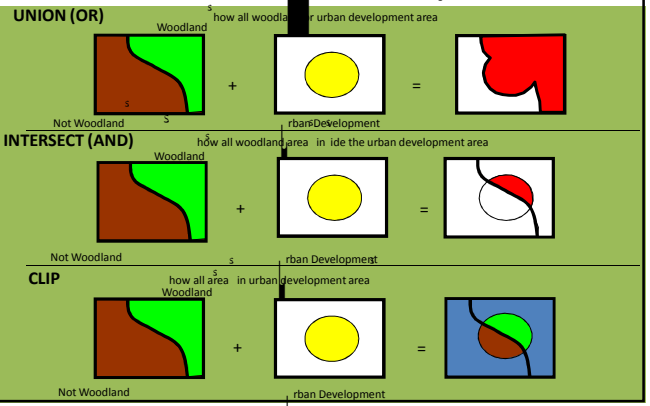
Polygon Overlay

- Complexity of polygon overlay wa one of the greate t barrier to the development of vector GI .
- Example :
  - How much of a propo ed clear-cut (felled plantation) lie in a riparian zone
  - What proportion of A Land i owned by the Department of Land Affair



Clip, Inter ect and nion

- common way overlay are applied
- An wer and way in which attribute data are combined differ



A Problem in Vector Overlay

- Common feature are repre ented in both output layer . Doe not alway fit exactly
- I know a liver
- Longer calculation time and bigger attribute table .