Near Real Time Automated Generalization for Mobile Devices

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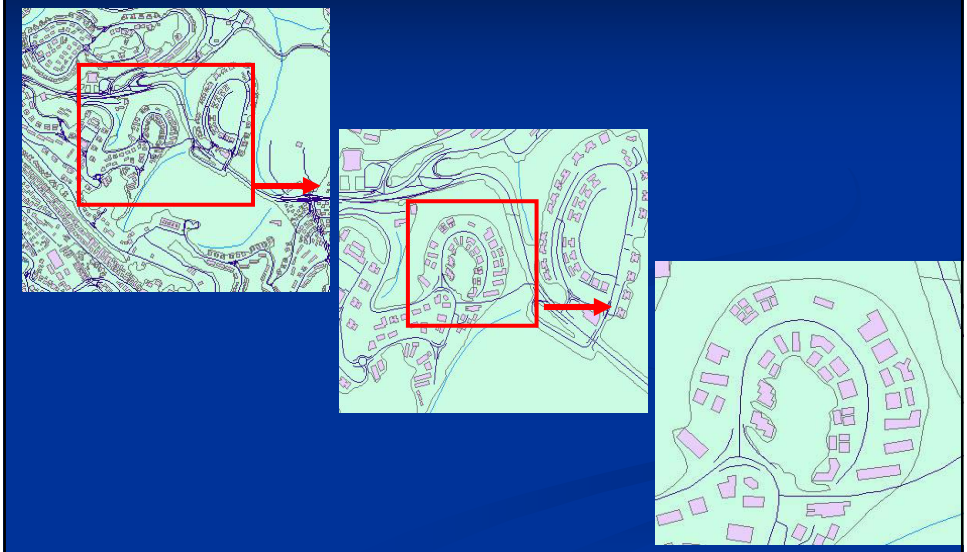
Digital Maps on Mobile Devices

- The substantial amount of geospatial data in the form of digital maps which is available on the World-Wide Web.
- The huge number of mobile devices.

→ Development of modern techniques suitable to performing near real time applications on mobile devices.

Zoom in/out in Digital Maps



Real Time Digital Maps Presentation

- Multiple Representation/Resolution Database approach is applied usually in order to prepare in advance digital maps at different scales.
- Multiple Representation/Resolution Database approach requires a complex updating process as all predefined maps in the different levels (scales) should be updated simultaneously.

Automated Cartographic Generalization

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Cartographic Generalization Automation

Problems:

- Non formalized problem, constraints and rules.
- Implicit relative importance for each map object that controls the handling of the conflicts.
- The same conflict can be solved differently according to the involved objects and map target.
- Imitation of the decisions by a non formalized cartographer.

The Map as a Stage in an Area Warfare

- The generalization process causes an area warfare between the map objects.
- Each object protects its own surrounding area.
- Each object effects and is affected according to its relative importance according the specific map type.

Pseudo Physical Model for Automated Generalization

The model implements the electric field theory

$$F = \frac{G \cdot q_i \cdot q_j}{R^2}$$

In an electric field each "object" acts according to its power, affects its neighbors and is in turn affected by them.

The Model for Automated Generalization

- The model is intended to understand and describe the behaviour of active objects in the map generalization process.
- The study focuses on determining the relative importance "***power***" of each object in any given map.
- The interactions between the powers produce "***forces***" that control the objects behaviour according to the cartographic constraints, and solve spatial conflicts.

The Electric Field Theory

- Each object acts according to its power in the map presentation area. The power expresses its relative importance.
- Each object has its own surrounding field effecting neighbors objects who penetrate the object "effective hull", effect expressing the electric field.
- Forces are produced by the powers action and cause change of place or deformation of shape of the weak objects - in order to solve the spatial conflicts.

The Model Purposes

- To detect and solve spatial conflicts taking into account cartographic rules and constraints.
- To detect and retain special cartographic relationships such as perpendicularity and parallelism of cartographic objects.

- To make sure that no new conflict is added during the process.
- To prepare a near real time digital presentation at a desired scale.

Method of Performance

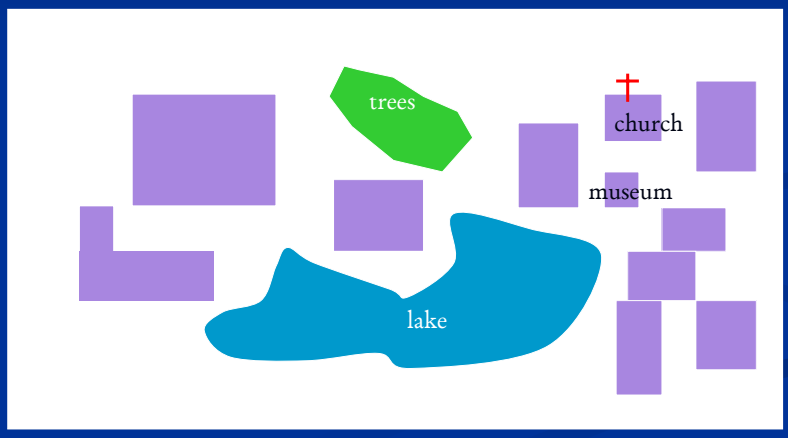
- In this study, the generalization process is controlled by the ***power*** of the objects.
- The ***forces*** are "developed" in each object as a result of the powers.
- Forces are “translated” to ***actions***, according to their value and direction to fit the generalization operator in respect to the process constraints.

Object Power Determination

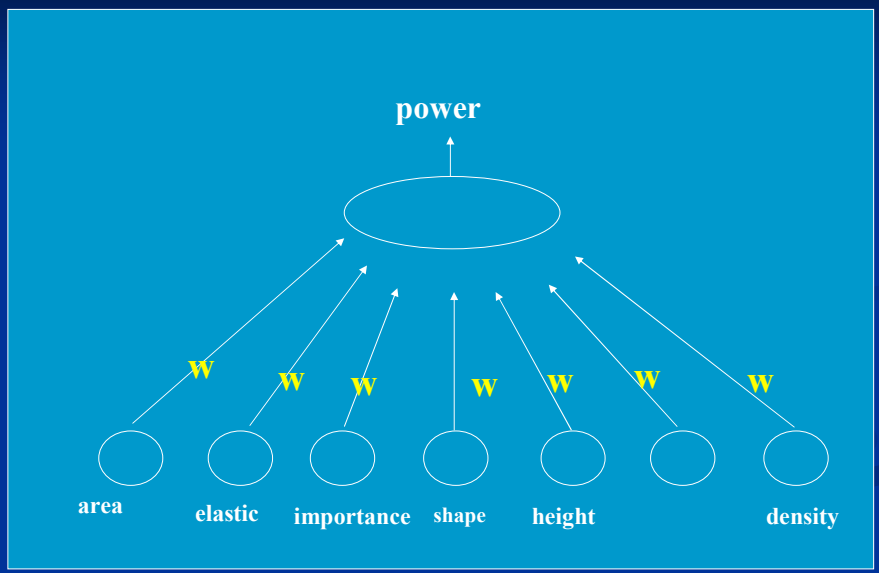
- The “power” is determined as a function of the object’s properties, location, and the surrounding area and objects.
- The action of the powers controls the object’s behavior, thus it has to be calculated carefully, taking into account all affecting elements.

Object's Power Determination

$$power = f(area, shape, hieght, elastic, Importance, density, ...)$$



Neural Networks



The Neural Network Example

The Neural Network Example

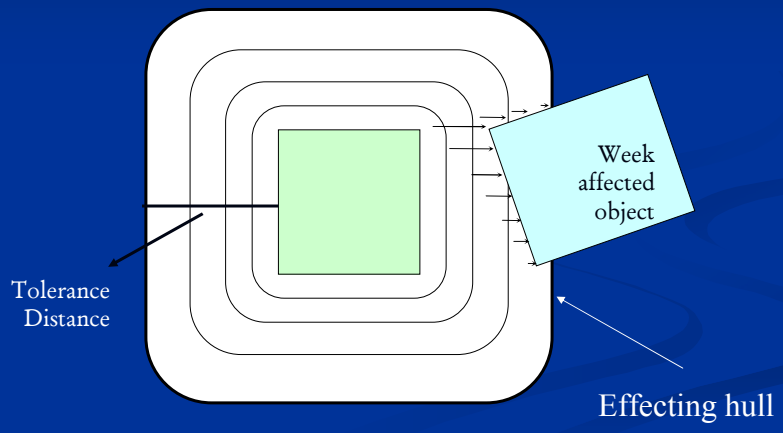
The Powers Interactions

- The power of each object acts on circumscribing "effective hulls".
- The interaction between powers product attraction and/or repulsion forces controlling its movements in relation to its neighboring objects.
- Each object is protected from the "stronger objects" and affects the "weaker objects" in its near vicinity.

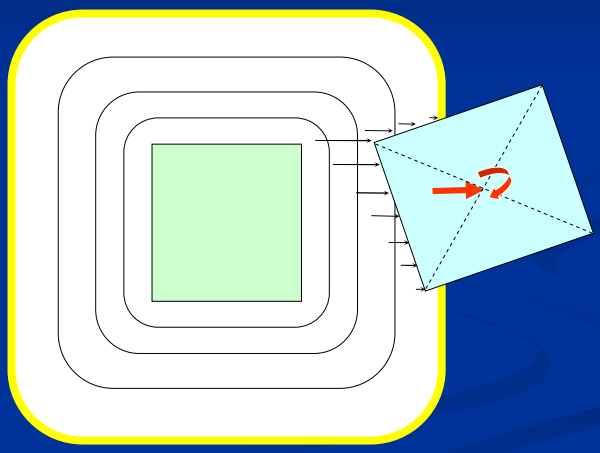
The Forces Action

- The affecting hull is composed of a number of shells; each one has its force effects as an inverse function of its distance from the object.
- The scattered forces act on the weak object per distance. The forces act only on the object's part in the tolerance effecting hull.

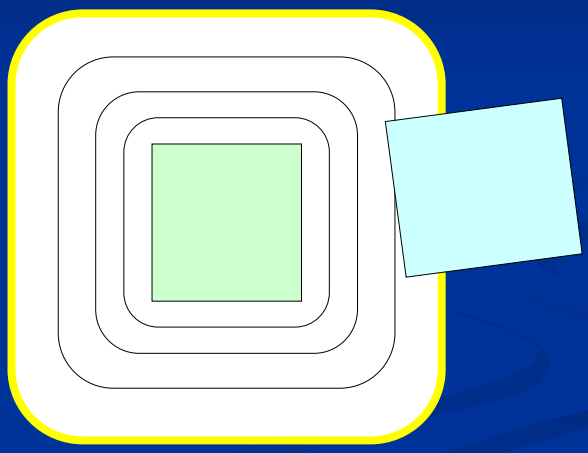
The Forces Effecting Hull



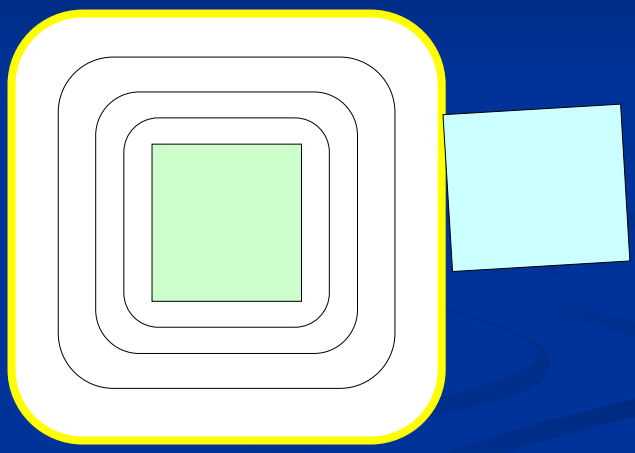
The Forces Action



The Forces Action



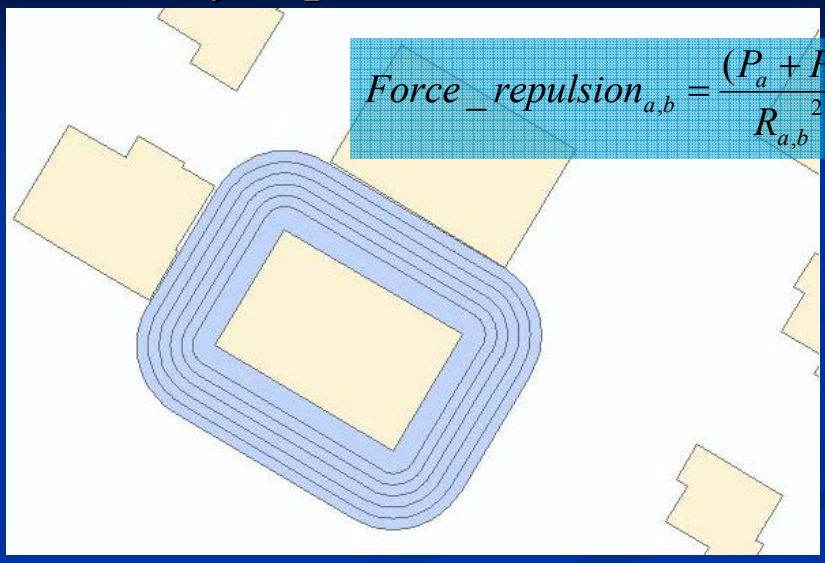
The Forces Action



Spatial Conflicts

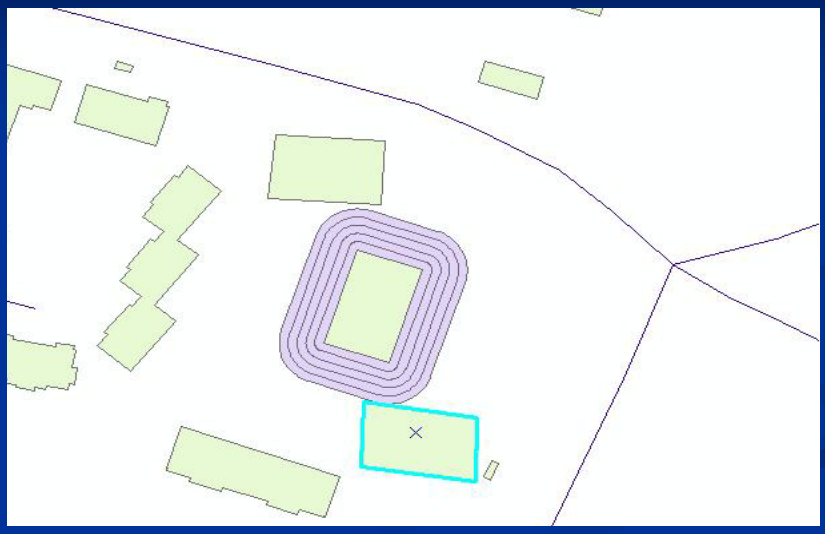
- Spatial conflict is detected when an object penetrates the other object's "effective hull", that causes the forces between the objects to act and solve the spatial conflict.
- Repulsion forces or attraction forces will act on the weak objects, thus cluster, move or reshape their cartographic symbol.

Movement by Repulsion Forces

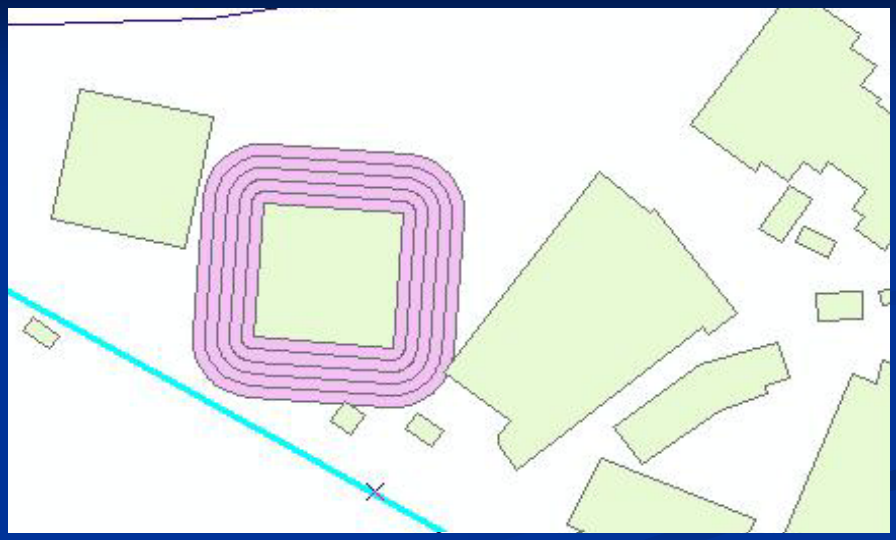


$$Force\_repulsion_{a,b} = \frac{(P_a + P_b)}{R_{a,b}^{\ 2}}$$

Rotate by Unsymmetrical Repulsion Forces

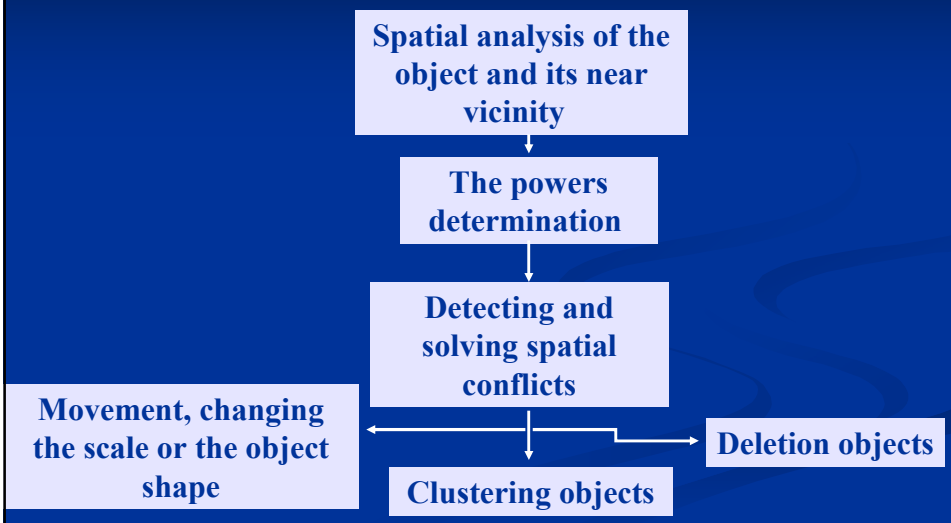


Combined Modification



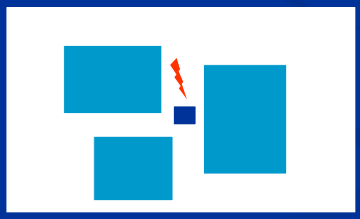
Cluster by Attraction Forces

The Pseudo Physical Model



Deletion objects

- Objects with minimum power and low relative importance according to the map type will be deleted.

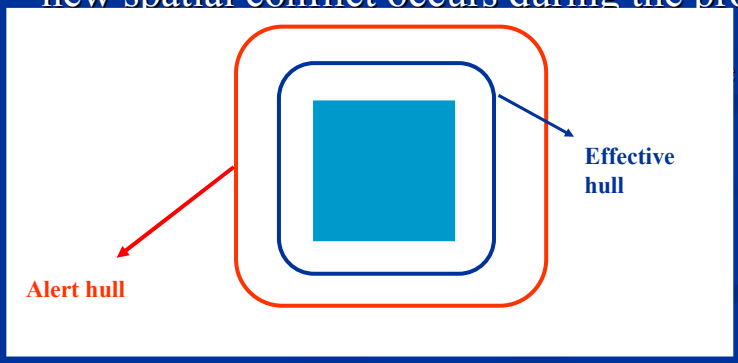


Clustering objects

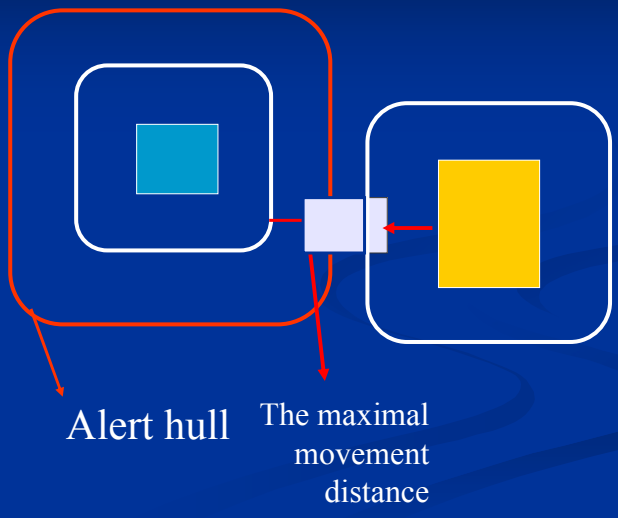
- Clustering is an important generalization operator
  - Clustering starts by detecting close edges
  - Clustering by moving weaker object toward the stronger object
  - Clusterin… calculati…
- The proces… …objects
  - from the… …gest

Repulsion forces action

- Each object has its effective hull, forces will act to move other objects out.
- Each object has its alert hull, to make sure no new spatial conflict occurs during the process.



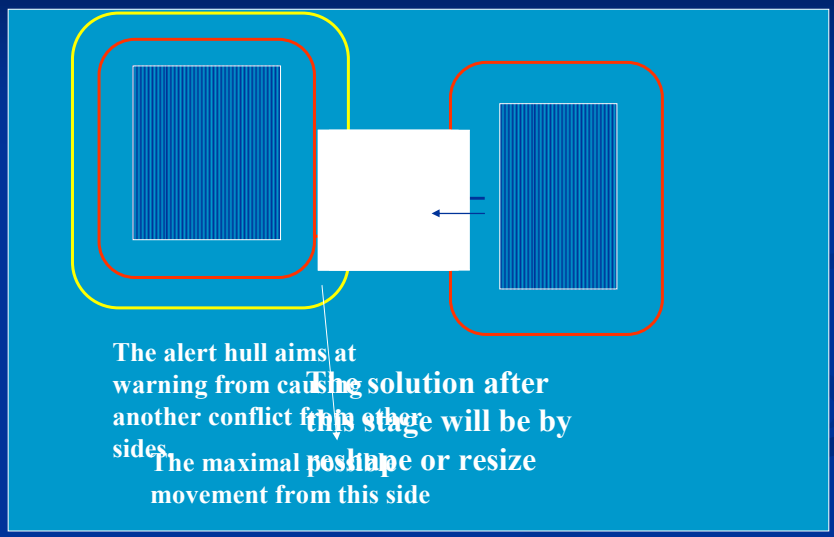
Alert Hull



The Repulsion Forces Action

- The model passes once over all the map objects handling the effect of the repulsion forces.
  - From the strongest → … → to the weakest
- The handled object will be treated according to all effects of its stronger neighbor objects.
- The process will move, reshape or resize the weak object in order to solve conflicts taking into account the boundary of the alert hulls.

Solving Conflicts



Results

6 May 2009 FIG 2009 Eilat 37

Results

6 May 2009 FIG 2009 Eilat 38

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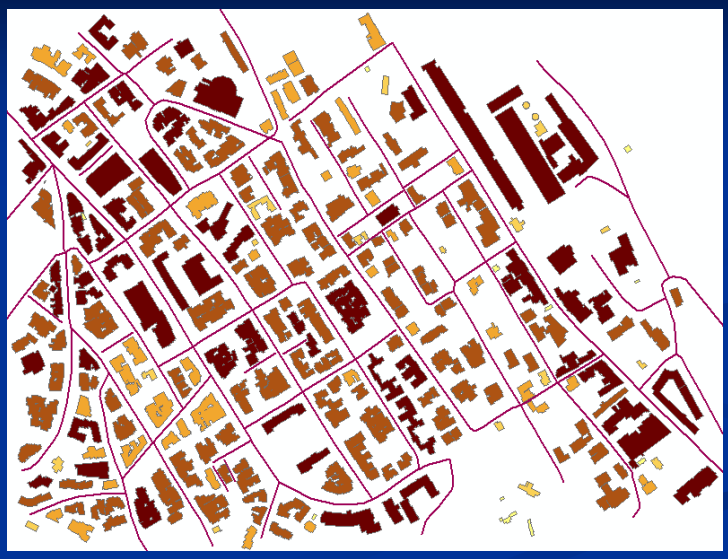
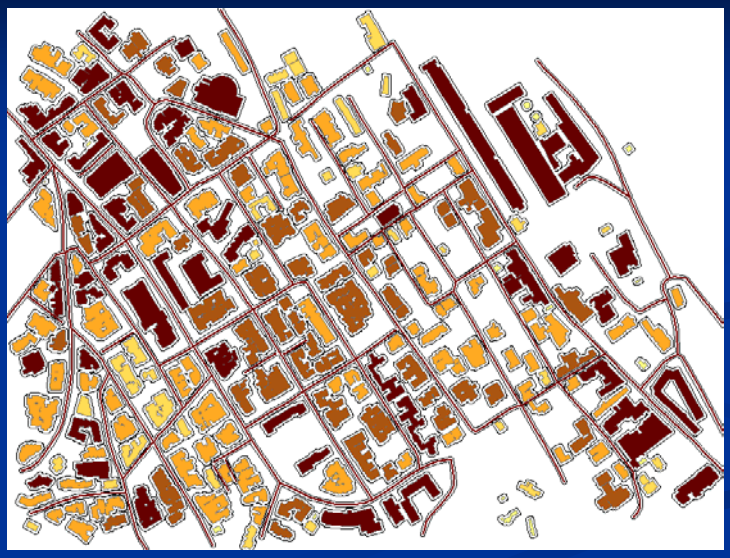
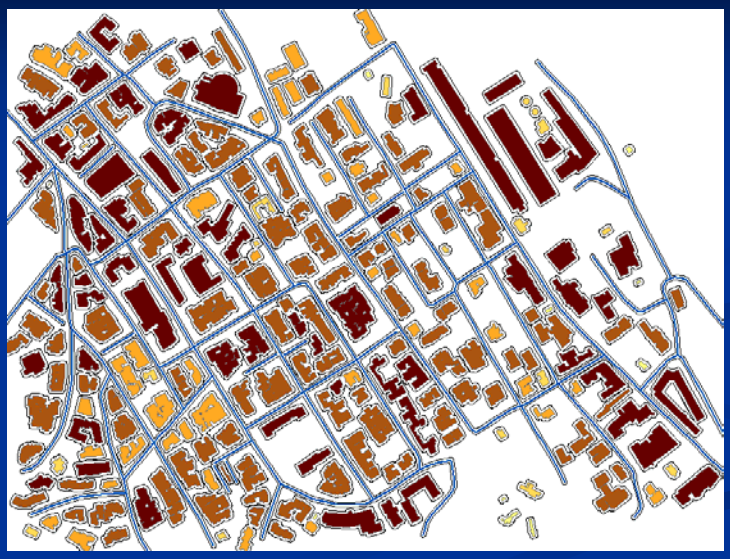


Results



Results



Results

Results of the Same Data in Several Scales

Summary & Discussion

- The algorithm examines the generalization process from a new standpoint that views the map as a stage in an electric field.
- The electric field theory enable to describe successfully the behavior of the map objects during the generalization process.
- The suggested model uses spatial data mining to understand the properties of objects and topology in order to determine their behavior.

Summary & Discussion

- The neural network sub model for power determination can be fitted to each user by inputting his own training data.
- The powers highlight the relative importance of the map objects and helps to retain the cartographic constraints.
- The method assures that no new conflict is added during the adjustment process due to “alert hulls”.
- The final result of the model is a near real time automated generalization process of digital maps.

Thank you

Any question ?