ArcGIS tool for creating equitable regions

AGIS – Geoinformatics Research Group

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Background

Feature grouping/regionalization in a meaningful way is often required in the domain of optimization and spatial decision support.

Scenario 1: Assisted evacuation planning

- The assisting providing authority has 2 evacuation units (vehicle) to cover the area.

An area to be evacuated
**Background**

**Scenario 2: Service coverage plan**

- A service provider wants to cover a certain area with their service.
- Assume that they can provide only 3 service centers of same capabilities.
- Interested to divide the area into 3 equitable regions.

**Area to be covered by service**

- Total population: 100
- Total floor space: 1500 m²

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Problem statement

Task

→ A geographic area $G$
→ Defined by a feature set consisting of $n$ number of connected/non-connected features
→ With a numeric attribute $A$
→ Has to be completely divided into $N$ number of equitable regions

Geographic area $G$, Where $n = 25$
Numeric attribute $A = $ Population
Output equitable region $N = 4$
Problem statement

Criteria

1. Feature splitting is not allowed
2. Sum of $|\mathbf{A}|$ of each output region should be equal to $T \pm d$ (Except one region)

$$T = \frac{\sum_{f=1}^{f_n} |\mathbf{A}|(\mathbf{G})}{N}$$

$d \in D = \{q \in \mathbb{Q} | 0 \leq q < \text{MAX } (|\mathbf{A}|/(\mathbf{G})) \}$

3. The output regions should be disjoint, must not overlap

Geographic area $\mathbf{G}$, Where $n = 25$

Numeric attribute $\mathbf{A} = \text{Population}$

Output equitable region $N = 4$

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The algorithm

General overview

1. Region formation starts from a suitable corner of input dataset
2. It continues along the bounding line of the input dataset.
3. If all features along the bounding line are already classified into regions, region formation again starts from a suitable corner of unclassified features set
4. Continue the process
Step 1: Selecting the seed feature for first region

1. Create the bounding line of the input feature set
2. Select features that touch the bounding line
3. Distance calculation and store the max
4. Compare next max with previous max and store the higher one
5. After the loop the feature which has the max will be the starting feature

\[ A = \text{Population} \]
\[ N = 7 \]
Step 2: Formation of the first region

- Neighbor features get grouped together on the basis of minimum distance.
- This process continues until the sum of $|A|$ of the region becomes equal to $T \pm d$.

$A = \text{Population}$

$N = 7$

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Step 3: Seed feature selection for subsequent regions

1. Create a bounding line of previously formed region
2. Select feature which is closest to both bounding lines

\[ A = \text{Population} \]
\[ N = 7 \]
Step 4: Repetition of Step 2 and 3

1. Repeat step 2 and 3 consecutively until $N-1$ no of regions are formed.

2. The $N^{th}$ region is formed with the remaining features after the formation of $N-1^{th}$ region.

$A = \text{Population}$

$N = 7$
Step 5 (if necessary): Recommence from step 1

\[ A = \text{Population} \]
\[ N = 13 \]

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Implementation and Result

\[ A = \text{Population}, \ n = 341, \ N = 3 \]
\[ \text{SUM} (|A|) = 3654, \ T = 1218, \ d = 0-21 \]

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\[ A = \text{Population}, \ n = 341, \ N = 7 \]
\[ \text{SUM} (|A|) = 3654, \ T = 522, \ d = 0-21 \]
Performance

Processor: Intel i5 @ 2.60 GHz
Memory (RAM): 8 GB
Operating system: Windows 7, 64 bit
Conclusion and future works

1. The algorithm is applicable for polygon and point features set.
2. Dealing with multiple attributes would be interesting future works.
3. The algorithm could be further enriched by introducing constraints (e.g. major roads, other important structure etc.)
4. Moreover, computing time for larger input datasets could be improved with techniques like spatial indexing.
Thank you for your attention!!

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Related works

Automated Zone Design (AZD)

1. Automated Zonig Procedure (AZP) (Openshaw, 1977)
2. Modifiable Areal Unit Problem (MAUP) (Openshaw, 1984)
3. Automatic Zone Matching (AZM) (Martin, 2003)

Main Task of the algorithms

- Aggregation of N zones into M regions (N>M)
- Based on an Objective Function
- Works by iteratively combining and recombining zones into regions
Related works

Problems of AZD we addressed in our algorithm

- AZD would not work in a discrete dataset
- AZD works only with a connected feature set
- A topological contiguity is therefore required
Content

1. Background

2. Problem statement

3. Related works

4. The algorithm

5. Implementation

6. Concluding remarks
Implementation and Result

As an Add-In for ArcGIS 10.1
Application Programming Interface (API): ArcObjects
Programming Language: c#
Add-in Implemented in: ArcGIS 10.1