Understanding hotspots

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Understanding hotspots

- Definition of a hotspot
- Hotspot mapping techniques
- Defining crime hotspots
- The next generation of hotspot mapping techniques …
What is a hotspot?

• Geographical area of higher than average crime or disorder
  – Area of crime or disorder concentration, relative to the distribution of crime and disorder across the whole region of interest (e.g. district, BCU)
  – Hotspots are areas of clusters of crime or disorder that can exist at different scales of interest
Continuous surface smoothing

- Interpolation – estimate the value at unsampled locations based on the values at sampled locations

- Weather stations
- Temperature readings (intensity or z value)
- Temperature surface
Continuous surface smoothing

- Crime data
- “estimate the value at unsampled locations based on the values at sampled locations” – does not make sense

- Create a surface based on the distribution and density of our crime points
Kernel density estimation

Source: Ratcliffe, 1999
Comparing KDE to other methods

• Results from research
  – Prediction Accuracy Index

![Hotspot map](image)

**Figure 3.** Hotspots were determined by selecting the uppermost thematic class calculated using the five classes and the default values generated from applying the quantile thematic range method in MapInfo.

<table>
<thead>
<tr>
<th>Hotspot mapping technique</th>
<th>Average PAI (01/01/2003)</th>
<th>Average PAI (13/03/2003)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial ellipses 250m</td>
<td>1.74</td>
<td>2.25</td>
</tr>
<tr>
<td>Spatial ellipses 500m</td>
<td>1.24</td>
<td>1.52</td>
</tr>
<tr>
<td>Spatial ellipses HSD</td>
<td>1.69</td>
<td>2.03</td>
</tr>
<tr>
<td>Thematic mapping of output areas</td>
<td>1.91</td>
<td>2.38</td>
</tr>
<tr>
<td>Thematic mapping of grids 250m</td>
<td>2.00</td>
<td>2.34</td>
</tr>
<tr>
<td>Thematic mapping of grids HSD</td>
<td>2.06</td>
<td>2.63</td>
</tr>
<tr>
<td>Kernel density estimation</td>
<td><strong>2.90</strong></td>
<td><strong>3.41</strong></td>
</tr>
</tbody>
</table>

Values in bold indicate the highest values and values in italics indicate the lowest PAI values. Results are presented for each of the dates when hotspot maps were generated. These results show that KDE consistently produced the best hotspot maps for predicting future events.
Comparing KDE to other methods

Table 7  PAI values for different hotspot mapping techniques, by crime type

<table>
<thead>
<tr>
<th>Hotspot mapping technique</th>
<th>Residential burglary</th>
<th>Street crime</th>
<th>Theft from vehicle</th>
<th>Theft of vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) PAI values calculated from the 1 January 2003 measurement date</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial ellipses 250 m</td>
<td>1.38</td>
<td>2.36</td>
<td>2.18</td>
<td>1.65</td>
</tr>
<tr>
<td>Spatial ellipses 500 m</td>
<td>1.34</td>
<td>1.46</td>
<td>1.54</td>
<td>0.82</td>
</tr>
<tr>
<td>Spatial ellipses HSD</td>
<td>1.43</td>
<td>2.45</td>
<td>2.12</td>
<td>1.29</td>
</tr>
<tr>
<td>Thematic mapping of output areas</td>
<td>1.10</td>
<td>4.20</td>
<td>1.17</td>
<td>1.18</td>
</tr>
<tr>
<td>Thematic mapping of grids 250 m</td>
<td>1.70</td>
<td>4.04</td>
<td>1.82</td>
<td>1.37</td>
</tr>
<tr>
<td>Thematic mapping of grids HSD</td>
<td>1.68</td>
<td>3.46</td>
<td>2.12</td>
<td>2.06</td>
</tr>
<tr>
<td>Kernel density estimation</td>
<td><strong>2.31</strong></td>
<td><strong>4.68</strong></td>
<td><strong>2.29</strong></td>
<td><strong>2.32</strong></td>
</tr>
<tr>
<td>(b) PAI values calculated from the 13 March 2003 measurement date</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial ellipses 250 m</td>
<td>1.32</td>
<td>2.59</td>
<td>2.15</td>
<td>2.93</td>
</tr>
<tr>
<td>Spatial ellipses 500 m</td>
<td>1.31</td>
<td>1.40</td>
<td>1.55</td>
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<td>3.58</td>
<td>2.43</td>
<td>1.66</td>
</tr>
<tr>
<td>Thematic mapping of grids HSD</td>
<td>1.95</td>
<td>4.14</td>
<td>2.55</td>
<td>1.89</td>
</tr>
<tr>
<td>Kernel density estimation</td>
<td><strong>2.33</strong></td>
<td><strong>4.59</strong></td>
<td><strong>3.66</strong></td>
<td><strong>3.05</strong></td>
</tr>
</tbody>
</table>

Values in bold indicate the highest values and values in italics indicate the lowest PAI values. These results show that KDE consistently produced the best hotspot maps for predicting spatial patterns of crime for all crime types, and that in some cases STAC was not the worst performer. Instead, thematic mapping of output areas generated the lowest PAI values for residential burglary, and in one case for theft from vehicles.
Comparing KDE to other methods

Figure 4. Hotspot maps generated from 3 months of residential burglary input data (measurement date of the 1 January 2003) using (a) STAC, (b) thematic mapping of output areas, (c) grid thematic mapping and (d) KDE. Each map is shown with its PAI value, based on 1 month of measurement data.
Defining hotspots

- Crime generators
- Crime attractors
- Crime enablers
Defining hotspots

- **Crime generators**
  - Where people congregate
  - **Place:** Lots of people
  - **Offenders:** Lots of opportunities
  - **Victims:** Lots of unprotected targets
  - Examples: Shopping malls, transport hubs
Defining hotspots

• Crime attractors
  – Where specific opportunities or crime services exists
  – **Place:** Well known for particular opportunities
  – **Offenders:** Good reputation for success
  – **Victims:** Fit the profile of the particular opportunity
  – Examples: Street prostitution, drug areas, robbery
Defining hotspots

• Crime enablers
  – **Place**: Where there is little regulation of behaviour
  – **Offenders**: Easy to carry out their actions, rules of conduct are absent or not enforced
  – **Victims**: Isolated or exposed
  – Examples: Car parks, park pavilions, back seat of the bus
Defining hotspots

• How do you distinguish between different types of hotspots?

<table>
<thead>
<tr>
<th></th>
<th>Number of crimes</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crime generators</td>
<td>HIGH</td>
<td>LOW</td>
</tr>
<tr>
<td>Crime attractors</td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
<tr>
<td>Crime enabler</td>
<td>LOW</td>
<td>HIGH</td>
</tr>
</tbody>
</table>
Defining hotspots
Middlesbrough - Theft from shops
Defining hotspots
Middlesbrough - Theft from shops

Crime attractor
(high vol; high rate)

Crime enabler
(low vol; high rate)

OS AddressPoint ‘shops’ as the denominator
The next generation of techniques

- Spatial significance testing
  - Identify what really is hot
  - **Thursday: Spatial significance mapping**

- Generating rate maps not constrained to artificial boundaries (i.e. Considers underlying population as points rather than aggregated to a geographic unit)
  - E.g. Dual KDE and GAM/K

- Integrating temporal component to hotspot analysis
  - Not Knox and Mantel! – only tells you something interesting has happened in space and time, but not where or when …!
  - Where and when were there crime concentrations that were significant - see work by Renato Assunçâo and Martin Kulldorf

- Whilst all hotspot maps look at the past, provides one of the best methods for predicting the future
Where can I get more details?

- **Understanding hotspots** (2005), Eck, Chainey, Cameron, and Wilson. US NIJ free publication

- **GIS and Crime Mapping** (2005), Chainey and Ratcliffe

Summary

• Lost of different techniques
  – Some are better than others
  – Accuracy and visual presentation: KDE

• KDE: still only describes a pattern
  – Next step involves understanding why there is a hotspot
  – Defining the hotspot is a useful step forward in helping to do this

• Need to begin to consider other techniques that provide an extra, more robust dimension:
  – Spatial significance mapping: Thursday
  – Space and time
Thankyou

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