The remote sensing data offers a uniform measurement over a large area.

Remote sensing provides direct measurement of various geophysical properties, such as reflectance, emission and absorption of electromagnetic energy.

These geophysical properties are *partially* controlled by things of interest to epidemiologists, such as vegetation.

The actual remote sensing data can be used directly or ....
- It can be classified.
- It can be integrated into models.
- It can be converted into products.
The sensor measures multiple wavelengths at each pixel. All energy within a pixel for a wavelength band pass is integrated to a single integer in the range $0 - 255 (2^8)$. Each band is independent. The Thematic Mapper (TM) has 7 bands. For the TM a pixel is measured in 7 dimensions with a precision of $2^8$ bits. In theory each pixel could have any one of $(2^8)^{7}$ values.

This is a very, very big number.

In practice the bands are correlated and all the available dynamic range is not used. Practically, each pixel has only one of $(2^7)^{4}$ possible values.

This is merely a very big number.
Classification is a way to reduce the dimensionality and precision to something a human can understand.

The names used come from a FEATURE SPACE. The names and the feature space are abstractions!

Conversion from scalar to nominal loses information and introduces error.
The "I hope I am right" option

How strong is the relationship between the nominal designation (the class) and some "objective" standard?

Classification creates a statistical connection between scalar data and a feature space

Start with the scalar geophysical measurement

Classification is NOT required

YES classified

YES supervised

YES assess accuracy

YES relationship

NO

NO

NO

NO

A

B

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**Sources of Classification Error**

Most classifications have average errors in the range of 25 – 40%.

Example:
"Forcing a square peg through a round hole."
Only two classes are permitted, plain (low number) or hashed (high number). So pixel (2,3) is what?

Example:
"Variables don't and constants aren't."
The measurements always have "noise". Note the values in pixels (1,1), (1,2) and (2,1).

<table>
<thead>
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<th></th>
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<th>2</th>
<th>3</th>
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</tr>
<tr>
<td>3</td>
<td>35</td>
<td>18</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: there is a white rectangle used to clip the diagonal shading.
This can cause some fascinating and entertaining problems.

Most logical algorithms assume REAL domain input.

The raw satellite data are INTEGER.

Example:

This can cause some fascinating and entertaining problems.
Binning ALWAYS creates artifacts

What are the relationships between points C, D and E?

If the data are binned to the values \( i_2 \) and \( i_3 \), the true relationship are obscured AND spurious information has been added.

Actual function

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In a review of publications applying remote sensing to epidemiology

- most were found to use classification
- none gave any information about the accuracy of the classification.

Therefore, their results

- can only reveal how their health data related to their subset,
- they don’t really know what that subset is,
- nor do they know if the subset can be reproduced!

It is strongly recommended that epidemiological studies utilize the full information content of the remote sensing material.

- This means using the full dimensionality or some statistically defensible expression of the total or a derived product.
- The computational burden, which 25 years ago was huge, is now easily handled by ordinary desktop systems.
Contacts & Acknowledgement

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