Total Solar Eclipse of 1994 November 3
taped at La Lava, Bolivia by Fred Espenak
How to find loops in the solar corona

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The Problem: crucial for constraining solar physics parameters

The Real Problem: loops are hard to detect objectively

The Solution: the perfect is the enemy of the good

The Problem with the Solution
The Problem

The Solar corona is highly structured
SOLAR
CORONA
Fe XV 284 A
2 MK
SOHO/EIT

2004/07/07 13:06
The Problem

The Solar corona is highly structured

It is dominated by loop like structures that overlap each other
The Problem

The Solar corona is highly structured

It is dominated by loop like structures that overlap each other

The contrast is low, and the structures are dynamic
The Practical Problem

A loop detection algorithm does not exist

Loop identification is done by “hunting and pecking”

Analyses are unstable and not reproducible
The Solution

If you torture them enough, the data will confess.

Morphological processing to extract identifiable features

- enhance contrast
- morphologically open loop-like structures
- apply threshold
- group contiguous pixels into blobs
  - make skeleton
  - prune skeleton
TRACE image

enhance contrast by background subtraction
(like unsharp masking)
enhance contrast by background subtraction

open with rotating rectangles
open with rotating rectangles  
background subtracted and thresholded
background subtracted and thresholded

converted to bitmap and percolated into regions
grouped into regions and selected

skeleton pruned and overlaid on data image
The Solution

Morphological processing to extract identifiable features

- enhance contrast
- morphologically open loop-like structures
- apply threshold
- group contiguous pixels into blobs
- make skeleton
- prune skeleton
- estimate error
sensitivity analysis

0.10 0.20 0.30 0.50 0.70 0.90 0.95

$y$ [pix]

$x$ [pix]
In conclusion

But there are problems with the solution

You can only find what you already know exists

Connecting broken loop segments still requires manual intervention

Estimating the statistical significance of the detected features is rudimentary

Not necessarily the optimal heuristic
## Comparing with magnetic potential field model

<table>
<thead>
<tr>
<th>Loop</th>
<th>Emergent footprint</th>
<th>Descendent footprint</th>
<th>Length [10 Mm]</th>
<th>Temperature [K]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-0.23,0.49</td>
<td>-0.30,0.48</td>
<td>1.4</td>
<td>3.3</td>
</tr>
<tr>
<td>B</td>
<td>0.32,0.13</td>
<td>0.16,0.13</td>
<td>2.4</td>
<td>4.3</td>
</tr>
<tr>
<td>C</td>
<td>0.47,0.31</td>
<td>0.63,0.35</td>
<td>1.3</td>
<td>3.1</td>
</tr>
<tr>
<td>D</td>
<td>0.15,0.15</td>
<td>0.17,0.39</td>
<td>3.8</td>
<td>5.4</td>
</tr>
<tr>
<td>F</td>
<td>0.40,0.25</td>
<td>0.27,0.24</td>
<td>1.3</td>
<td>3.2</td>
</tr>
<tr>
<td>G</td>
<td>0.30,0.28</td>
<td>-0.04,0.12</td>
<td>10.8</td>
<td>4.5</td>
</tr>
</tbody>
</table>