Automatic vs. Human detection of Bipolar Magnetic Regions: Using the best of both worlds

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Active Regions

- Magnetic fields emerge from the Sun
- Pairs of positive and negative magnetic field
- Cause sunspots
- Crucial for the development of the solar cycle
- Active region properties



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Solar Cycle

11-year cycle of solar activity, 22-years total



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Active Regions and the Solar Cycle

- Cycle is a magnetic phenomenon
- Each Active Region contributes a little bit to the large-scale magnetic field of the Sun
- Collective action drives cycle
- Wish to understand statistical properties of Active Regions

Magnetic Fields in the Sun

Poloidal r - θ







Active Regions and Magnetic Fields



Effects of the Solar Cycle

- Heats upper atmosphere of Earth
- Increased/Decreased number of solar flares and coronal mass ejections
- Possible effect on climate



Data

- SOHO/MDI data from 1996 to 2011
- Black regions indicate a negative magnetic field
- White regions indicate a positive magnetic field



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- 1. Detection of positive and negative regions separately
- 2. Aggregation into active regions based on size, flux and distance
- 3. Tracking of active regions across magnetograms

Human vs. Computer

- Humans have evolved to be very good at finding patterns but can be subjective
- Computers are not as good at recognizing patterns but are more consistent and objective





Project

- Combine the pattern-finding skills of a human with the consistency of a computer
- Computer detects positive/negative regions and performs initial pairing and tracking
- Human reviews results and makes corrections

Ultimate Goal: Create a database of active regions for the study of the solar cycle

 Optimize the computer's ability to detect, pair, and track active regions

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eros_size = 3.0

eros_size = 9.0

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Best Combination

Developing the Interface

Coded functionality to allow human intervention



Corrected Mistake





Active Region Detections Movie



Hale's Polarity Orientation Law

Only 5% of active regions violate this law





Joy's Active Region Tilt Law

Average tilt increases with latitude





Dipolar contribution of Active Regions

 Some active regions have a conflicting contribution





Where do we go from here?

- Statistical analysis of AR flux and tilt with aims at better understanding cycle propagation
- Assimilation of our catalog into solar cycle models with aims at earlier and more accurate cycle predictions
- Assimilation of our catalog into coronal and solar wind models with the purpose of studying the connection between the solar cycle and changes in the heliosphere

QUESTIONS?

Sources

- Cambridge Encyclopedia of the Sun
- "The Solar Cycle" by David M. Hathaway
- Images:

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