U. Hawai`i iterative approach to ambiguity resolution.

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History:

• Initially developed by U. Hawai`i "solar group" in late 1980s/early1990s for the Haleakalā Stokes Polarimeter (HAO's old Stokes II).

• As support for the Yohkoh project, the HSP obtained many magnetograms *daily* which were desired by many researchers on the Yohkoh team.

• An algorithm which could be automated, fast, and have a physical basis was required to allow physical interpretation of the vector field data.

• Basic algorithm is published as an appendix in Canfield et al, 1993 ApJ.

Physical approach and justification.

- Objective/Justification based on choosing a solution consistent with minimum energy, minimum complexity.
- Start with the solution most consistent with a constant-α force-free field.
    - Caveat: solar photospheric fields are neither constant-α nor force free.
    - Caveat: the best-α depends on ambiguity resolution.
- Iterate solution by minimizing:
    - Angle differences between adjacent pixels
    - Divergence of the field.
        - Caveat: no height information generally available.
    - Vertical current density.

Basic Algorithm:

(1) Initial solution: pick the direction closest to potential field using the B*los* as the boundary condition.

(2) Transform to heliographic coordinates; use new Bz as boundary condition, compute the force-free field with specified α (default: $\alpha = 0$); pick direction closest to the new constant-α force-free horizontal field.

(3) Optional: perform acute-angle test. For each pixel, in an order specified by the user, chose direction which maximizes Σ ($\boldsymbol{B} \cdot$ neighbor $\boldsymbol{B}$).

(a) Using dot product weights neighbors by their respective field strengths.

(b) Iterate until no more “flips” or maximum number of iterations.

(4) Optional: perform current/divergence minimization. Compute dBx/dx + dBy/dy and $|Jz|^2$ = ***grad*** x ***Bh.***

(a) For each pixel, chose the direction which minimizes either or both.

(b) Iterate until no more “flips” or maximum number of iterations.

(5) Optional: “regions of conflict” can be displayed and direction flipped by hand.

(a) Cumbersome, and presently not repeatable.

Some specifics:

- Written in IDL; freely available as part of a larger ambiguity-resolution and force-free extrapolation package "mgram.tar" at ftp.cora.nwra.com/pub/metcalf??
- There are a gazillion keywords and options. In this way the algorithm is very customizable, but also repeatable. Examples:
  - Chose α for force-free field comparison.
  - Chose starting point and order of pixels for iterations.
  - Use a provided azimuth determination and (optional) do no further optimization
  - Do/do not perform the acute angle, divergence, current tests.
  - Use the vertical/line-of-sight field for the force-free field computation
  - Quiet/Verbose/Interactive/Stand-Alone operation.
- 200^2 pixels takes approx 1-2 minute on a 1.9 GHz processor
  - Depends on number of iterations before converging, options chosen, *etc*.

KD's General Modus Operandi:

• Unless the data are obviously close to potential, perform "get_alpha.pro" on B*los* & B*trans*.

• Use the resulting α to specify the force-free field, with center of largest, simplest spot as "radial point". Include minimization of current/divergence.

• Perform "get_alpha.pro" on ambiguity-resolved heliographic ***B*** map, make sure result is similar to the original. Ambiguity-resolution can change the answer dramatically. If this is the case, repeat ambiguity resolution with new α.

• Check results for unphysical looking line-currents, gradients, etc. If there is a region of conflict in a strong-field area, start playing with keywords/options to obtain a "better" solution.

• For time-series data, a set of keywords/options is selected to ensure a consistent ambiguity resolution between time-steps.