SECCHI 3D Reconstruction and Visualization Team: Organization and Approach

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World of 3D Reconstruction and Visualization

Medical

Industrial

Scientific

STEREO 3D R & V

↗

SECCHI 3D R & V

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Belgians
JPL
Lockheed
MPAE
NRL
Independents

3D Reconstruction and Visualization

3D Reconstruction:

Stereoscopy (Tie Points): EUVI

Identification in two images of positions of individual points (tie points) and application of trigonometry

EUVI: High contrast loops and small features, relatively small heights above an optically thick disk (hard surface stereoscopy)

Tomography: White light coronagraphs Cor 1, Cor 2, HI (HI 1 and 2)

3D grid of electron density N_e and 2D CCD image array:

CCD Image (l,m) = $\int_{LOS}$ { Thomson Scattering (N_e , event and K background, position x,y,z, solar photospheric intensity) + F background } × Instrument Response × Temporal Smearing × Noise $d\ell$

Will call tomography the inversion of CCD images to give N_e (x,y,z)

Visualization:

True stereo visualization with EUVI and coronagraphs

3D display of volumetric parameters

Coordination of displays of SECCHI and other STEREO observations (particles, fields)

SECCHI 3D Reconstruction and Visualization Team

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MAXIMALLY COORDINATED TOTAL STEREO SCIENCE PROGRAM: this will be developed by a much larger group of scientists, but we can have an important input !

Color: wavelength dependence of solar spectrum, instrumental wavelength response (Thomson scattering itself λ independent)

Special considerations with HI:

> Geometry: HI (HI 2 especially) LOS not toward center of solar disk. Limited common volume observed by both spacecraft (**Sockergram FIGURE 2**)
>
> Instrumental: Signal-to-noise
>
> Viewing of Earth-directed CMEs: real angular coverage around CME possible with HI 2

Execution speed of computer procedures, possible BEOWULF configuration (factors of >4 improvement by 2004??)

IDL standard language? No standard language?

Coordinate system definitions (solar, spacecraft)

Others

White Light Tomography with Coronagraphs

Need a white light renderer, 3D reconstruction engine

Renderer: procedure to create model CCD images from arbitrary viewing angles of a prescribed 3D electron density distribution

Reconstruction engine: procedure employing the reconstruction algorithm selected (the NRL approach will be discussed later)

Solution is the electron density distribution which optimally matches CCD images:

CCD images → Reconstruction engine → Trial N_e distribution → White light rendering → Comparison of model with real CCD images → Iterate

Need to get right:

Physics

Geometry

Use of two polarizations in optimal solution

Backgrounds (**FIGURE 1: upper left original LASCO C3 image, upper right background, lower left subtracted image, lower right 5 × subtracted image**)

K, F, time-averaged of both for shorter-duration "events"

Temporal simultaneity and smearing (**TABLE 1**)

Goals for Pre-Launch Study with Our 3D Reconstruction Algorithms

Apply to model structures (where we know correct answer) of increasing complexity and realism

Apply to theoretically generated structures (CME models, equatorial streamers, whatever, where again we know the correct answer)

Apply to old LASCO observations to model long-lived structures where one viewpoint and rotation can mimic simultaneous observations from two viewpoints (background models, equatorial streamers, polar plumes, others?)

Execution timing for different CCD pixel binnings, N_e gridding: procedures must be realistically computable during actual mission

Effect of spacecraft angular separation on reconstruction

Are some science goals more appropriate for different times in the mission?

Improvements possible with movies: closely spaced pairs of exposures where successive reconstructions of an evolving event are not radically different

Pointing jitter effects

Exposure times and signal-to-noise issues

Others

TABLE 1

SECCHI	1 pixel (arc sec)	2000 km s^{-1} (cross 1 pixel)	Outer FOV	1 $R_\odot$ ~ 2.3 s Δt
EUVI	1.4	0.5 s	1.5 $R_\odot$	3.5 s
Cor 1	7.5(2x2)	2.5 s	4 $R_\odot$	9 s
Cor 2	15	5 s	15 $R_\odot$	35 s
HI 1	35(2x2)	7 s		
HI 2	120(2x2)	40 s		

For each telescope (col 1), this table gives transit time across 1 pixel at 2000 km s^{-1} (col 3), and rough maximum time difference in speed-of-light arrival times at two spacecraft in the commonly observed volume (col 5; the geometry of HI FOV makes this more complex, and HI is left out)