Northeastern (46th Annual) and North-Central (45th Annual) Joint Meeting (20–22 March 2011)

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Presentation Time: 8:00 AM-12:00 PM

BEST-FIT STRAIN FROM MULTIPLE ANGLES OF SHEAR AND IMPLEMENTATION IN A COMPUTER PROGRAM FOR GEOLOGICAL STRAIN ANALYSIS

VOLLMER, Frederick W., Geology, SUNY New Paltz, New Paltz, NY 12401, vollmerf@newpaltz.edu

An analytic solution to the Wellman (1962) construction was desired for a 2D and 3D strain analysis program, EllipseFit 2, designed for field-based strain studies and structural geology labs. Oriented images are digitized using center-points, five-point ellipses, polygon-moment ellipses, or line segment pairs. Techniques include center-to-center (Fry, 1979; Erslev, 1988) with ellipse-fitting, Rf/Φ (Dunnet, 1969) and polar (Elliott, 1970) graphs. Best-fit ellipse calculations include shape-matrix eigenvalues (Shimamoto and Ikeda, 1976), mean radial length (Mulchrone et al., 2003), and hyperboloidal vector mean (Yamaji, 2008), with error analysis. Fitting of section-ellipses to ellipsoids is done using Shan's (2008) method.

A Wellman construction (1962) is used to determine strain from pairs of initially orthogonal lines. Ragan and Groshong (1993) gave a trigonometric solution for two angles of shear, however the tangent function makes this numerically unstable, so an analytic geometry solution was derived. For two line segments, *p* with endpoints $(x_0, y_0)^T$ and $(x_1, y_1)^T$, and *q* with endpoints $(x_2, y_2)^T$ and $(x_3, y_3)^T$, *p* and *q* are translated: $p' = p - (x_0 + 1, y_0)^T$, $q' = q - (x_2 - 1 , y_2)^T$ so one endpoint of *p* lies at $(-1, 0)^T$, and one endpoint of *q* lies at $(1, 0)^T$. The implicit forms for the two translated lines are: $a_1 x + a_2 y + a_3 = 0$, $b_1 x + b_2 y + b_3 = 0$, where: $\mathbf{a} = (y_0' - y_1', x_1' - x_0', x_0'y_1' - x_1'y_0')^T$, $\mathbf{b} = (y_2' - y_3', x_3' - x_2', x_2'y_3' - x_3'y_2')^T$. Solving these gives two diametrically opposed points *x*, *y* and -*x*, -*y* on the ellipse: $x = (b_1c_2 - b_2c_1) / (a_1b_2 - a_2b_1)$, $y = (a_2c_1 - a_1c_2) / (a_1b_2 - a_2b_1)$. For two pairs of line segments the strain can be solved directly. For two or more pairs the best-fit ellipse can be found by a least-squares minimization directly or by a LU decomposition to solve for the coefficients of the quadratic equation of a centered ellipse.

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