Dips

Graphical and Statistical Analysis of Orientation Data

Verification Manual

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Introduction

This document presents an example, which has been used as a verification problem for the program DIPS. DIPS is an engineering analysis program for the interactive analysis of orientation based geological data, produced by Rocscience Inc. of Toronto, Canada.

The result produced by DIPS agrees very well with the answer calculated from Microsoft Excel, and confirms the reliability of mean vector calculations produced by DIPS.

1.1 Introduction

The purpose of this verification problem is to establish the correct computation of means of groups of orientation planes by DIPS. The orientations in the verification are given in the Dip/Dip Direction format. The verification provides the data, the methodology for calculating mean orientations manually, and the results given by DIPS.

1.2 Orientation Data

The mean will be calculated for the following orientation planes:

#	*Dip*	*Dip Direction*
1	68	118
2	63	109
3	53	119
4	76	106
5	70	118
6	61	101
7	72	102
8	52	112
9	74	117
10	67	113

1.3 Calculations

Calculation of the mean of a group of orientations is done using the following steps:

1. Convert all orientations from *Dip/Dip Direction* format to unit vectors $\mathbf{V}_i = (x_i, y_i, z_i)$ using the relationships

    $x_i = \sin(Dip)\sin(Dip\ Direction)$

    $y_i = \sin(Dip)\cos(Dip\ Direction)$, and

    $z_i = \cos(Dip)$

2. Determine the mean of each component of the unit vectors. For example, the mean *x*-component is calculated as

    $$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N},$$ where N is the number of vectors (in our specific example $N = 10$).

3. Normalize the resulting vector so that it has a magnitude of one, i.e. it becomes a unit vector

    $$\bar{x}' = \frac{\bar{x}}{\sqrt{(\bar{x})^2 + (\bar{y})^2 + (\bar{z})^2}}, \quad \bar{y}' = \frac{\bar{y}}{\sqrt{(\bar{x})^2 + (\bar{y})^2 + (\bar{z})^2}}, \text{ and } \bar{z}' = \frac{\bar{z}}{\sqrt{(\bar{x})^2 + (\bar{y})^2 + (\bar{z})^2}}$$

4. Convert the normalized mean vector $\left(\overline{x}', \overline{y}', \overline{z}'\right)$ into *Dip/Dip Direction* format using the relationships

$$Dip = \cos^{-1}\left(\overline{z}'\right)$$

$$Dip\ Direction = \cos^{-1}\left(\frac{\overline{y}'}{\sin(Dip)}\right)$$

The spreadsheet below shows the calculations for the data supplied.

#	Dip	Dip Direction	x	y	z	
1	68	118	0.818655	-0.43529	0.374607	
2	63	109	0.842463	-0.29008	0.45399	
3	53	119	0.698502	-0.38719	0.601815	
4	76	106	0.932708	-0.26745	0.241922	
5	70	118	0.829699	-0.44116	0.34202	
6	61	101	0.85855	-0.16689	0.48481	
7	72	102	0.930274	-0.19774	0.309017	
8	52	112	0.730631	-0.29519	0.615661	
9	74	117	0.85649	-0.4364	0.275637	
10	67	113	0.847329	-0.35967	0.390731	
			0.83453	-0.32771	0.409021	*(Mean components)*

Normalized mean

0.846844	-0.33254	0.415056

Mean Orientation

65.4771	111.4391

1.4 Dips Results

Figure 1 below is a DIPS plot of the input orientations and the location of the global mean orientation.
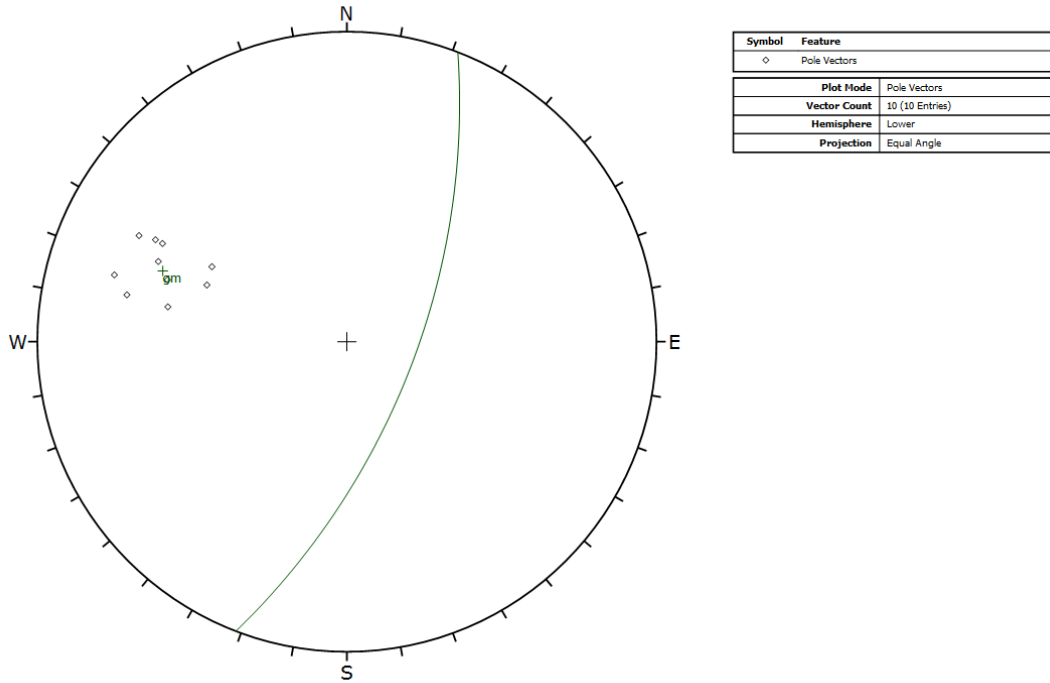

Figure 1: Pole plot of input orientations and location of their mean.

The global mean orientation calculated by DIPS (as reported in the Info Viewer) is shown below:

Global Mean

	Dip	Dip Direction
Unweighted	65.48	111.44
Weighted	65.48	111.44

It can be seen that DIPS reports a mean orientation which is identical to that obtained from the spreadsheet calculations.