An automated fracture trace detection technique using the complex shearlet transform

General comments

This paper describes a new method to automatically interpret fracture traces from 2D images (e.g. drone acquisition) using a novel technique. After explaining why an automated approach is better than manual interpretations, the method is briefly described in the main text and in more details in an appendix. The method is then applied to three different areas from different quality and resolution of images. Results are compared to manual interpretations. Finally advantages, disadvantages and way forward are discussed.

The paper is globally well organized, well written and easy to read despite some technical terms which are not clearly explained for the reader not familiar with these techniques. The figures are also globally well-presented although some of them would require some clarification. The abstract clearly summarizes the paper. A random check of the references did show any errors. The appendix is beyond my competence for a thorough review.

Considering the importance of such automatic interpretation methods and, from my knowledge, the original technique used, I accept this paper pending minor revision which are given below. My main concern is that if the (non-mathematician) reader can conclude that this shearlet transform allows convincing and fast automatic interpretation of fracture traces, he does not understand how physically it works.

Introduction

Page 2 – line 2-6

Geomechanically derived DFNs are based on the physics of fracture propagation (Olson et al., 2009; Thomas et al., 2018) and can reproduce realistic fracture patterns providing the complex paleostress field and paleo rock properties are known. ~~*; however*~~*,* T*hey are* also *computationally intensive and hence have limited applicability. A carefully chosen fractured outcrop that is relatively free of noise (fractures resulting from exhumation and weathering* and not too much hidden by vegetation) *may be used to interpret realistic fracture networks which are geometrical inputs used in simulating various subsurface* thermo-hydro-mechanical-chemical processes (THMC) *processes.*

Background

2.2 The Complex Shearlet Transform

A shearlet definition for dummies (the simple geologists) and/or a simple analogy would be welcome in this chapter since it is the heart of the method. This chapter is reproduced from different references which are fundamentally mathematical hence difficult to understand for non-mathematician readers.

Page 5 – line 11

CoShREM with Canny, Sobel, phase congruency: ????

Methods

3.2 Shearlet parameter selection

The parameters which finally control the quality of the final fracture trace extraction are briefly described in Table 1 but their role and their physical meaning is not clear to me. Could it be possible to represent them on a figure (e.g. as part of Fig. 1).

Page 6 - line 25

We use the structural similarity measure (SSIM) : explain what it physically means or at least give a reference.

Page 6 - line 29-30

Mexican hat wavelet support: ???

Octave: ??? not defined even in Table 1.

Results

Page 8 - Line 30

there is a tendency to interpret and link together disconnected features from the original raster image.

Could it be possible to show differences in fracture length distribution between automatic and manual interpretation? (also valid for the other examples)

Page 9 – line 4

(see Fig. 10a, 10b*)*

Page 9 – line 11

is shown in Fig. 10~~bc~~

Page 9 – line 16

*Fig. 10*d *depicts the P_{21}*

Page 9 – line 22

comparison between both ~~the~~ vectorizations

Page 9 – line 22

no real evidence of rock ~~displacement~~ failure

Page 10 – line 16

which are comparable in quality to the manual interpretation of Thiele et al. (2017) : these manual interpretations are no shown so it is difficult for the reader to make his judgement.

Discussion

Page 11 – line 10

King (2019), blob detection measures : not clear what it is

Page 12 – line 2-4

K. Bisdom (2016) gives some relations between distance, resolution and camera length size which could be useful here (Burial related fracturing in sub-horizontal and fold reservoir – TU-Delft PhD thesis – ISBN 978-94-6186-740-7).

Since we are here in the suggestion part, you could also advise to make, if possible, 2 or 3 flight acquisitions at different altitudes to define resolution further.

Page 12 – line 5-17

The use of MPS is to mean important complement of the interpretation results. MPS could also be used to fill regions with false positives related to e.g. shrubbery.

Appendix A

This is beyond my competence. I cannot review this part.

Figures

Figure 1

Could be complemented by a drafted explanation of the shearlet transform parameters

Figure 4

In this present format, this figure does not mean anything for the basic reader. I suggest to shift it to the appendix and to replace it by the concrete effect of these parameters on the fracture trace extraction of a simple fracture network.

Figure 5

Could it be possible to add an image showing lineaments color coded as function of the relative number of time that they have been detected by each realization?

Figure 8

Figure 8b is not readable. I suggest 1) remove the photo underneath and 2) improve the contrast of the color scale (e.g. a three color legend bar scaled between 0 and >5 since it seems that there are very few zones above this threshold).

Figure 9

Again, try to improve the P21 color scale contrast

Figure 10

Same comment for 10d as for 8b

Figure 11

What is manual and what is automatic is not indicated. Put the fracture traces in white for better distinguishing them from the photo lineaments

Figure 12

(a) *Bingie Bingie Area ~~2~~* 1