Pixel Size Determination for Seismic Exploration in 2D Seismic Line Design

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Abstract

Here is presented a methodology based on axioms for the 2D seismic exploration using new line seismic design of Colombia. For future seismic exploration is recommended the 2D regional seismic design. Then, an algorithm for quantification and integration data was implemented. After that, was established the methodology for the optimal pixel size from scale function, its fractal geometry and the volume information. This is possible to realize the transformation of the different layers of information. For it were planned to mapping different kind of information: slopes, fold and distribution, so on.
It is necessary that the layer information would be in a similar data format, it is possible make a change in the form, appearance by means a transform. Data transform contains the different layers in raster format. The seismic line transform was realized by an algorithm that measure the quantity of and obtain a layer with information density of seismic line.

Introduction

The seismic exploration offered some onshore and offshore possibilities, but does not exist a visualization about the need to explore areas renewed the interest in a tracing of seismic line possibilities. There are important characteristics for make decision, some methodology and their problem solution is maintained (Lopez et al., 2008). In this case it is presented an integration, mapping and seismic design using an algorithm implementation. In the seismic line design the most relevant feature is a map where the seismic lines are acquired in the study zones. This line information is a monochromatic image and it contains each pixel that it is classified in binary form (zero 0 or One 1). For this kind of information is planned a strategy for classify and determine the pixel size with probability to be used without bad sampling and computationally viable information dimension, for treatment it.

A lot of works about image analyses, the pixel size is determined by the visual perception limit (Fernandez, 2005), which related that scale map with pixel size, but no analytic form the other way standard values for image diverse.
In this case the regional seismic line drawing follow a methodology, it imply that all the parameters considered could be in a raster matrix format, converting the size of the pixel in the key for development this methodology. The sampling of the information and its volume are the topics that characterize the size pixel. This study is based in hypothetical model of the seismic lines to different lines to different dips or slopes (Figure 1).

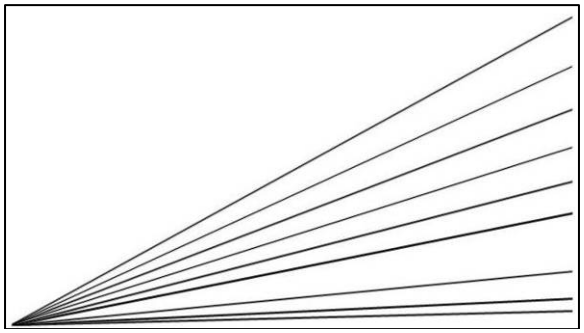

Figure 1 – Hypothetical model of the seismic line with different direction.

Area

A survey plan for all Colombia was suggested. It comprises 26 sedimentary basin of Colombia (ANH, 2006). According the data collected (seismic lines, head well, gravimetric, magnetometry, communities, geology, bathymetry, topography, environments, geomorphology, so on) could be established a analyses of information using an algorithm implemented by the seismostratigraphy group. It permits delineate and tracing the geophysical parameters and design of the 2D seismic lines (Figure 2).

The design examined herein was aimed at exploring the quantification and implementation of 2D seismic design that include the sedimentary basin of Colombia. For this, it is important considering the limit perception. This characteristic is the measure which the human vision perceives variations of physical information (Drury, 1993). This measure is approach to 0.2 mm of magnitude.

Determining the pixel size which rasterizing the different layers of information could be made a calculation to determine according scale, that dimension could be identified.

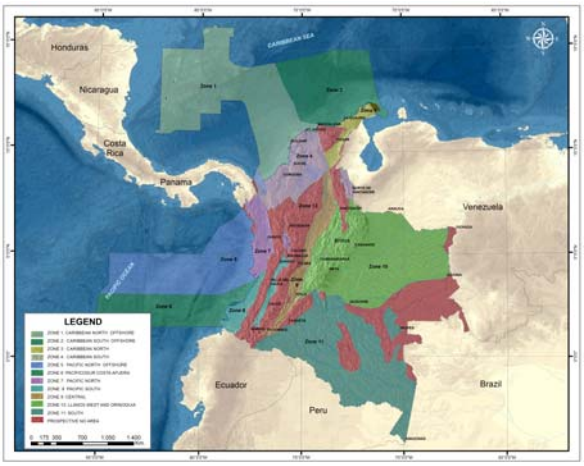

Figure 2. Sedimentary Colombia Basin and prospective zones according to Report PISSCO 2010-2020 Volume I, (Modified from ANH, 2010).

With this paper a tracing 2D design method is supported. Using it, is possible including or remove information for the survey. The seismic exploration include very large datasets, high resolution and mapping. The quantification and visualization allow to propose a set of guidelines for future surveys generation. The algorithm allows mapping datasets, according level of detail. The mapping worked is scaled to 1:1'000.000. According the human perception could be identified distance upper to 200m. In the case of the highest scale up to 1:250.000 the boundary would be 50m, being this value the beginning to determine the size of the pixel (Figure 3).

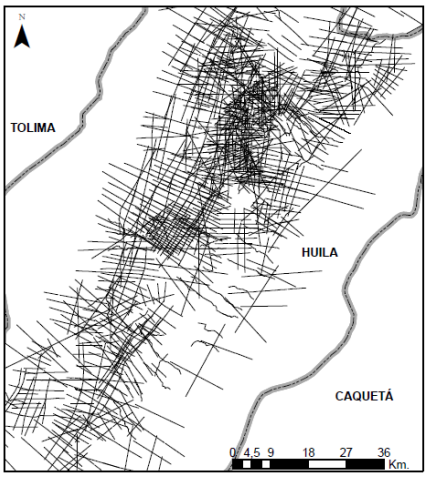

Figure 3. Map of seismic lines to scale 1:1000000. In the contained areas it is appreciated the effects of the one it limits of perception.

The Box counting method is useful to determine the fractal properties of 1D, 2D of an image or a 3D matrix. If C is a fractal group, fractals with dimension FD lower than D, then the box number N of size R need to cover the fixed value in $R^{(-FD)}$. (FD is known like Minkowski-Bouligand, Kolmogorov or fractal dimension).
For the fractal line case they indicate that the form or the measure of a fractal line fill a plane portion.

Fractal Dimension (FD) Counting Box Method

The box counting method (Sarkar and Chaudhuri, 1992, 1994), is a way to determine the fractal dimension in a metric space (X, d), it is the simplest routine counts the number of boxes needed to cover one pixel wide. The fractal dimension can be understood as a measure of geometric self-similarity (Caneva and Smirnov, 2004). It consists in calculating the partial or total graphic form that contain. It establish a Cartesian coordinate system that contain the point assemble of the image that we want to analyze, after that proceeds to count the quantity of square 1/2n that intercept the point assemble.

Development

The pixel size determination is two implications: the first one, the size implies the sampling of the information and the second one, the quantity data to process (Crosta, 1992). A lower pixel size, the image would have high sampling, but like it was explained the human vision no identify a higher sampling information. This two implications are necessary to determine the pixel size.
It will be realized the study with hypothetical data, which it is representing different lines with diverse angles (Figure 4), being it the representation of the difficult referred to the sampling and the information transform of points to pixels. They could present aliasing of the information. Seismic lines are spatially distributed, either as vector (points, lines) or a raster data. Those lines are generated by design and digitizing map object. It could be obtained from irregularly-distributed samples gridding (Trauth, 2006).
For this model is presented this axiom: the lines with 45 degrees (independent of the pixel size), the line would be a injective function, by this reason the average value of the slope is 1.
For this case, in the sample in x , always increase in one unit, converting the equation in:

$$m = \frac{y_2 - y_1}{x_2 - x_1}, \quad donde \qquad m = y_2 - y_1 \tag{1}$$

$$\overline{m} = \frac{1}{n}\sum_{i=1}^{n} y_{i+1} - y_i \tag{2}$$

Calculating the average value of the slope of each one of the straight with different pixel size and graphic in function of the angles, could be observed that the variation of each one of the curves is not significant, so the pixel take a new magnitude order.

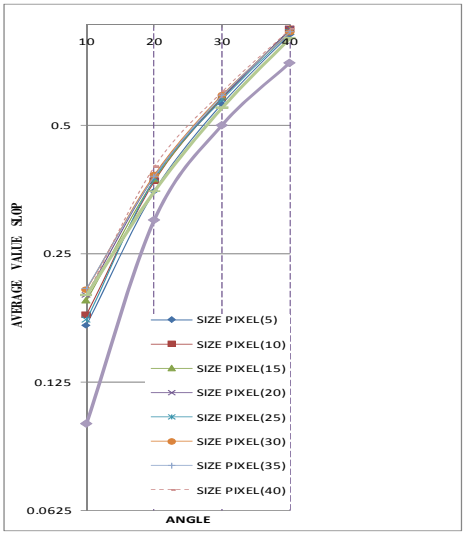

Figure 4. Average value of the slope vs angle

The curves on the figure 4, showed a symmetry. To identify it could be realized the calculate of the fractal dimension of the different straight with different pixel size.

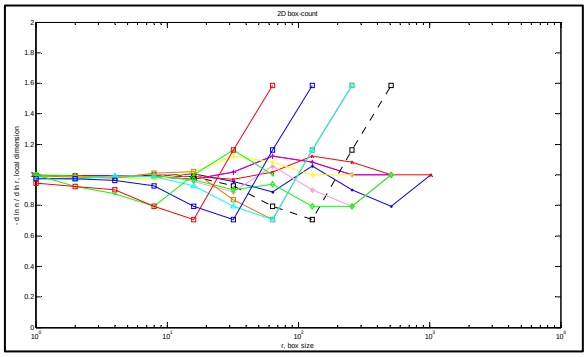

Figure 4. Fractal dimension for a straight to 40^0 decline.

Algorithm for Quantified

Seismic lines was in text format and reclassified for Matlab lectures. An study information is realized in matricial form, due that this zone could be analyzing by separated. After that, it could be correlate the different analyses obtained with each variables.
An algorithm was designed collecting exiting information. For the algorithm development was used the Von Neumann and Moore neighborhood like a base, it presented the neighbor geometry. Depending of the kind of information and the possible extrapolation was necessary consider the neighborhood grade worked or was implemented a higher neighborhood level.
A program was design based in the equation (3), realizing different tests for development the algorithm. Where:

$$b_{(i,j)} = \sum_{j=0}^{\tilde{n}} \sum_{i=0}^{n} \sum_{-m}^{m} \sum_{-k}^{k} \left(\frac{a_{(i+k,j+m)}}{z} \right), \qquad (3)$$

$b_{(i,j)}$ is the density matrix of seismic lines, $a_{(i+k,j+m)}$, is the data matrix of the seismic lines, and z is a weight factor associated to the distance of the neighborhood m and k.

The next figure (Figure 5) is an hypothetical model of the seismic lines, that represent the input matrix data.

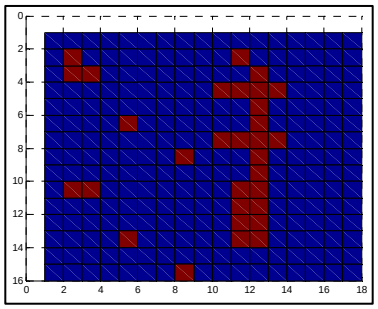

Figure 5. Hypothetical model of seismic lines.

After that, the idea was trying to quantify the information, for example, seismic lines. It was realized by mean of the calculate according the Moore neighborhood method (Figure 6).

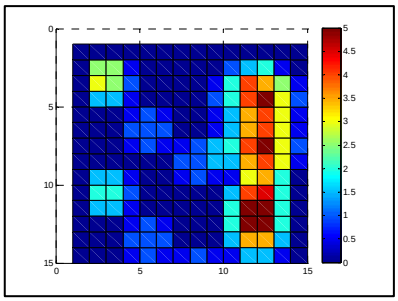

Figure 6. Diagram obtained with the Moore neighborhood.

Results

Considering the average variation of the slopes, could be perceived that this lines represents some trends. The variations are not significant for take decision, respect to the pixel size, then a fast answer would be a lower pixel size sampling and the obtain data do not confirmed it. The increase apparent of the deviation, that is the half value is

inversely proportional to the pixel quantity that is utilized for sampling the lines.
It is clear that the jump in the moment of increase the magnitude order of the pixel size and it is notorious the jump of the curve. The characterization of the lines by fractal dimension permit identified the different patterns and classify them according pixel size.
The sampling symmetry of each straight, is linked with the pixel size, it is found that the sampling is a succession:

$$a_n = 2^n(10) \ , \ b_n = 2^{n-1}(15) \qquad (4)$$
$$n = 0,1,2,3 \ldots \ldots$$

Where a_n and b_n are the sampling pattern.
The dimension fractal curve shows different patterns, someone does not have uniformity in their dimension, implying the lost of the fractal characteristic into the lines, them it converses in a new fractal specimen.
Considering the obtained data, it is used a 300m pixel and it is realized the following restrictions to equation 3, with the neighborhood of sixth order

$$si.....|k| \geq |m|.....z = |k|$$
$$si.....|m| \geq |k|.....z = |m|$$
$$si.....k, m = 0.....z = 1$$

In this form is obtained the figure 7. It shows the seismic lines acquired (Right lower side) in Colombian zone and the algorithm resulted from quantification of the information with the analyses and pixel size determination.

Discusion and Conclusions

In this paper it has presented a method allowing the design and tracing of seismic line for seismic exploration, using a multidiscipline MEC.
Determining the pixel size for this methodology exist three aspects: the human limit – perception who limit the minimum value pixel, the volume of information, for this case define the sampling, then a very small volume of data, the information will be bad sampled. The last one, the final decision of an optimum value of the pixel is fount intrinsically inside of fractal dimension curves, they showing what patterns maintain the sampling and the quantity of the information o realize the sampling.
The case of seismic lines in Colombia was used a scale of 1:1000000, the visual perception limit will be 200m the pixel, and according the fractal dimension the curve gather of pixel size 35, 70, 140 and 280 satisfy with the requirements, being the last the visual human perception. This gather indicate that the sampling form should be between points and straight, and a lot f proportion to different angles. Yet, has not been evaluated the 280 pixel, it generate the volume of data into the information that could be processed by the software; but this is not support the volume with this pixel size (overcharge the memory capacity). Like the following value for this family would be 560m is not possible. A near value that contains the requirements should be seeking. A near value was 300m by pixel; this value lost the data volume when it is executed, then the measure would be not drastic.

Acknowledgements

The authors would like to thank all the teams of ANH, seismostratigraphy group (UNAL, Colombia) and Mustagh Resources whose make possible this publication.

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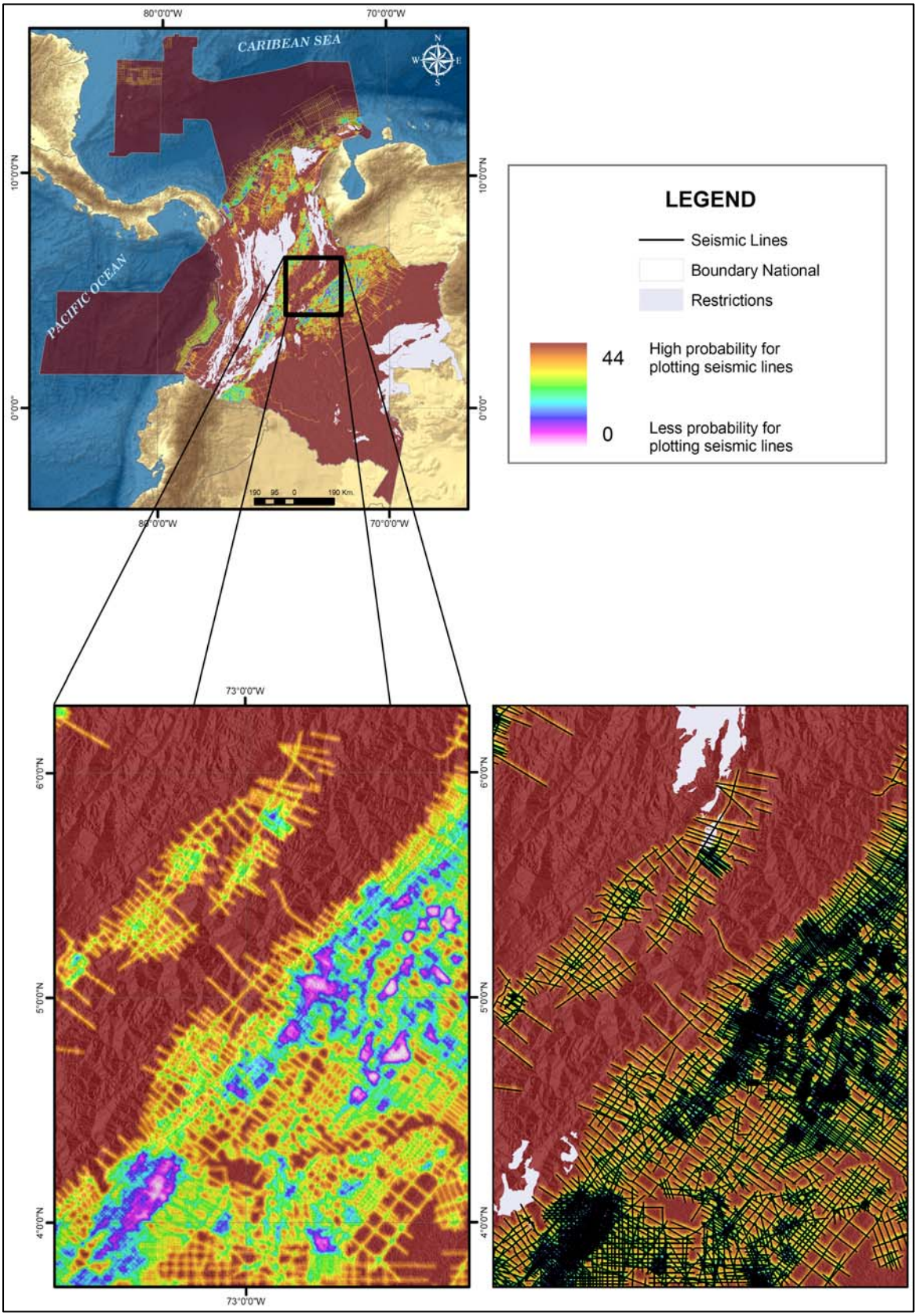

Figure 7 - Density of seismic line.