Pseudo 3D seismic using kriging interpolation

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Abstract. Seismic method is one of geophysical method that is used to determine subsurface condition of the earth. There are two types of seismic data, 2D seismic and 3D seismic. The advantages of using 3D seismic data is it has less uncertainty for imaging the earth subsurface. However, the cost to acquire 3D data is higher than producing 2D data, thus some company needs to invest more money to be able to get a better data quality. One of the ways to have 3D seismic data without having to spend a lot of money is by creating a 3D pseudo seismic data from 2D seismic data. The purpose of this research is to create a 3D pseudo seismic data by using a geostatistical method. The geostatistical method that is used in this research is Kriging interpolation. By the help of Petrel software, kriging interpolation is done to create the 3D seismic. The pseudo 3D seismic results show a good image such as difference in amplitude, also structural geology features of subsurface. In conclusion, the use of kriging interpolation in pseudo 3D seismic still needs more work and development so the results will be good for the next interpretation steps.

Keywords: Pseudo seismic, geostatistical, kriging, interpolation

1. Introduction
In seismic exploration, there are different kind of seismic data that can be obtained, that is two dimensional (2D) seismic data and three dimensional (3D) seismic data. A 2D seismic data only have an x and y directions horizontal component, meanwhile 3D seismic data have x and y horizontal components, and z vertical component which reflects time. In principle, 3D seismic data has more advantages over 2D seismic data, which is the 3D seismic data can image the earth subsurface better and it has higher resolution compare to the 2D seismic data. However, 3D seismic data also has disadvantage over 2D seismic data, that is the cost to do seismic acquisition for the data is much more expensive than to do acquisition for 2D seismic data [1].

To minimalize that disadvantage, there is an alternative way to overcome the problem which will be discussed in this paper, that is pseudo 3D seismic. Pseudo 3D seismic is a process which basically converting 2D seismic data by interpolating it into a 3D seismic data. Pseudo 3D seismic can be done by using geostatistical interpolation method.

In this paper, pseudo 3D seismic is done by using a geostatistical method that is kriging interpolation. The process interpolating 2D seismic data into 3D seismic data is helped by using Petrel software.
2. Kriging interpolation

Kriging is one example of that can be used to estimate value that represents a point that is not known based on the values from other sample points nearby by considering spatial variation as represented in the variogram.

Kriging is a method that gives the best unbiased linear estimation of point values or of block averages. There are several types of kriging estimators such as simple kriging, ordinary kriging, and indicator kriging [1].

Kriging interpolation gives an error and confidence value, this method uses semi variogram that represents spatial difference and value between all data sample. Semi variogram also shows weight which is used for interpolation. Semi variogram is measured based on semi variogram sample with distance $h$, value $Z$, and number of data sample $N$. Semi variogram equation can be written as the equation 1 [2]:

$$\gamma(h) = \frac{1}{2N_h} \sum_{i=1}^{N_h} (Z_i - Z_{i+h})^2$$  \hspace{1cm} (1)

At short distance, semi variance value will be small, but with increasing distance the semi variance will be higher. This shows that variation of $Z$ value has nothing to do with distance of sample point. There are several types of kriging interpolation, these are simple kriging, ordinary kriging, and universal kriging [3, 4].

1. Simple kriging, this type assumes that sample data have stationary mean and variance value and requires to input mean value.
2. Ordinary kriging, this type assumes that sample data have non-stationary mean value and stationary variance value.
3. Universal kriging, this type is an approach that is used for surface area trend interpolation.

3. Methods

In this paper, the pseudo 3D seismic process is done by the help of Petrel 2009 software. There are 3 steps to do this. The first steps are to create seismic framework from 11 seismic data that is inputted to Petrel. The purpose of this step is to restrict the top part and bottom part of seismic data that is going to be interpolated. The second step is to insert seismic property which is the amplitude into the seismic framework that has been created. The third step is to do structural modelling and property modelling.

Structural modelling is used for creating 3D geology model, this process is divided into several other steps that is fault modelling, pillar gridding, make horizons, and layering [5].

1. Fault modelling, this process is aims to perfect fault that has been picked to be processed further to be grid in 3D shapes.
2. Pillar gridding, is a process that is conducted to make 3D grid model framework. In this process framework skeleton is made and contains top, mid, and base of skeleton grid.
3. Make horizons, this process has the purpose to input horizon that has been picked into the pillar grid that has been made. In this paper, we made 4 horizons, in which 2 of them are the upper boundary and the bottom boundary of the pseudo 3D seismic.

Next step is property modelling, the process that is done in this paper are scale up well logs and petrophysical modelling [6, 7].

1. Scale up well logs, this process is intended to change object resolution or averaging variable value on the volume with smaller scale.
2. Petrophysical modelling, this process is used for interpolating the 3D section that has been scaled up by using geostatistical interpolation method, that is kriging.
4. Results and discussion
There are eleven 2D seismic data that is used for pseudo 3D seismic in this paper. Figure 1 shown the first step which is the making of the seismic framework from the data that has been input in Petrel. The seismic framework is made with z value is 2000. After that we do vertical resampling for all the data with resolution at 10, that is because the smaller the resolution the seismic image will be more detail. The seismic property is inputted into the framework by using assign values from seismic cube menu.

After the seismic property is inputted into the framework, the next step is the structural modelling, that is fault modelling (figure 2), there are 3 main faults that has been picked before and being modeled for 3D. The next step can be seen in figure 3, which is the making of horizons with make horizon menu on the seismic section, there are 4 horizons, 2 of them are acted as the upper and lower boundary. These horizons help the interpolation follows the geological condition of the research area.

![Seismic framework created from eleven seismic data](image1)

**Figure 1.** Seismic framework created from eleven seismic data

![Fault modelling created based on interpretation of fault in the seismic section](image2)

**Figure 2.** Fault modelling created based on interpretation of fault in the seismic section
The last step of making the pseudo 3D seismic is the extrapolation process, which is by using kriging. The kriging was controlled by the calculated variogram of the seismic amplitudes. The results can be seen in figure 4, we can see that in west part of the seismic section, it is dominated with high amplitude contrast, then in the bottom at the center part we can see geological structures like faults. And on the east part we can see the color is showing low amplitude which probably because of the noises on the seismic data.

5. Conclusion
Based on the results, we were able to process a 2D seismic data into a pseudo 3D seismic by using Kriging interpolation, but the result was really depending on the variogram analysis, data coverage and
seismic noise. The result of pseudo seismic shows the west part of the seismic section, it is dominated with high amplitude contrast, then in the bottom at the center part we can see geological structures like faults. And on the east part we can see the color is showing low amplitude which probably because of the noises on the seismic data. The use of Kriging interpolation in pseudo 3D seismic still needs more enhancement to be able to get a good result for the use in later stage of interpretation. The authors suggest reducing the seismic noise before the Kriging interpolation.

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