Probabilistic Seismic Facies: A Gaussian Mixture Model Approach- Canterbury Basin, offshore New Zealand

AASPI

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Introduction:

Visual examination of seismic facies on large 3-D seismic data sets where there is little *a priori* geologic information can be tedious and inaccurate. The process can be more automated and improved through the use of machine learning. By teaching a computer how to recognize patterns, features can automatically be picked. This has the obvious benefit of quicker interpretations, but moreover it can highlight features that might otherwise go unnoticed. The Gaussian Mixture Model (GMM) provides a flexible framework by which to accomplish this.

The Waka3D seismic survey was made public thanks to the New Zealand Petroleum and Minerals.

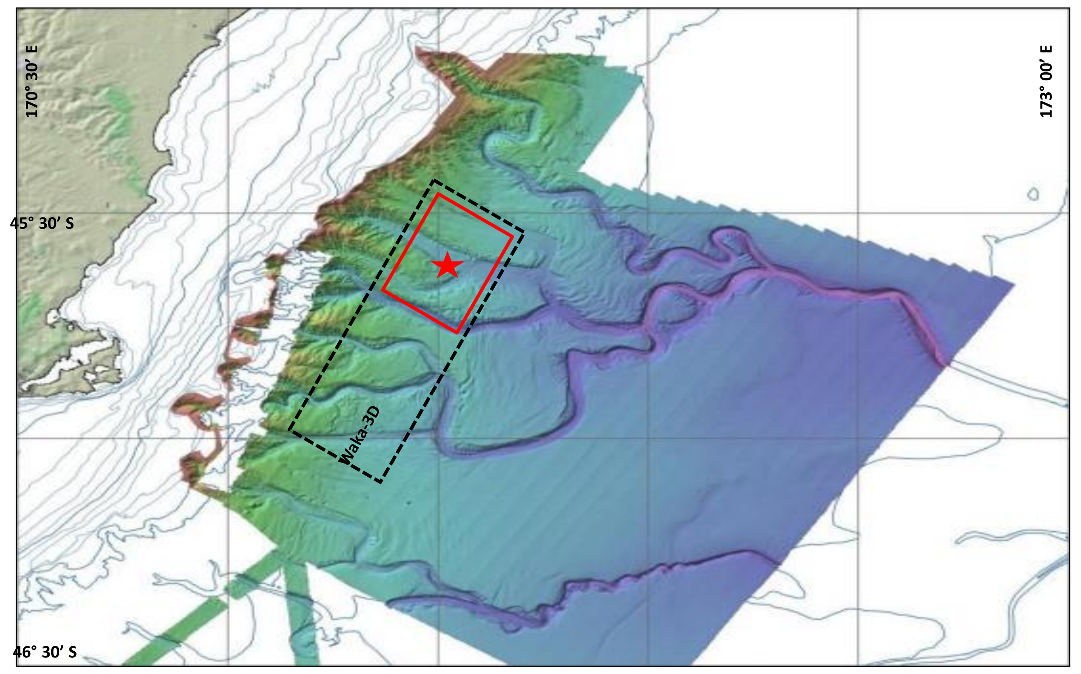

Figure 1 (above): Aerial view of study area. (Modified from Mitchell and Neil, 2012)

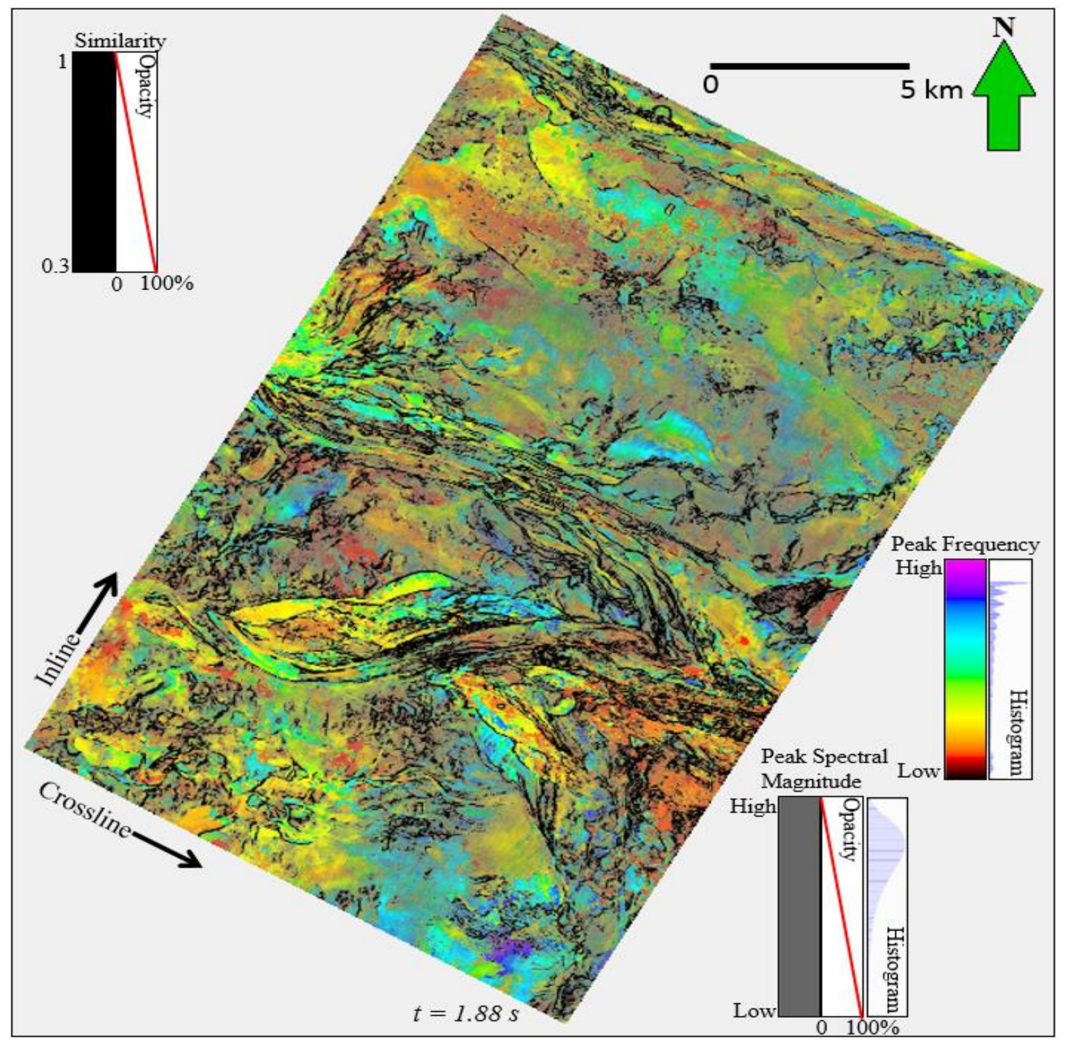

Figure 2: A multi-attribute time slice of the Waka3D data set. (Modified from Mitchell and Neil, 2012)

Geologic Setting:

The seismic survey is located on the Canterbury Basin, offshore New Zealand (Figure 1). More specifically, the area lies in the transition zone of the continental rise and continental slope. The data set contains many Cretaceous and Tertiary age paleocanyons and turbidite deposits. Sediments were deposited in a single transgressive-regressive cycle driven by tectonics (Zhao and Marfurt, 2014).

Gaussian Mixture Model (GMM):

GMM's are used to estimate probability density functions (PDF) using the weighted sums of Gaussian distributions. In this case, the GMM is being used as an unsupervised clustering algorithm. The parameters of each Gaussian, *N*, along with its weight, *α*, can be estimated using maximum likelihood and an expectation-maximization algorithm (Figure 3) (Zhao et al., 2015). The 1-D case of the GMM can be seen in Figure 4.

$$p(z) = \sum_{i=1}^{L} \alpha_i \mathcal{N}(z, \mu_i, \Sigma_i)$$

$$\mathcal{N}(z, \mu_i, \Sigma_i) = \frac{1}{(2\pi)^{P/2} |\Sigma_i|^{1/2}} e^{\{-\frac{1}{2}(z-\mu_i)' \Sigma_i^{-1} (z-\mu_i)\}}$$

Figure 3: Mixture Model Equations

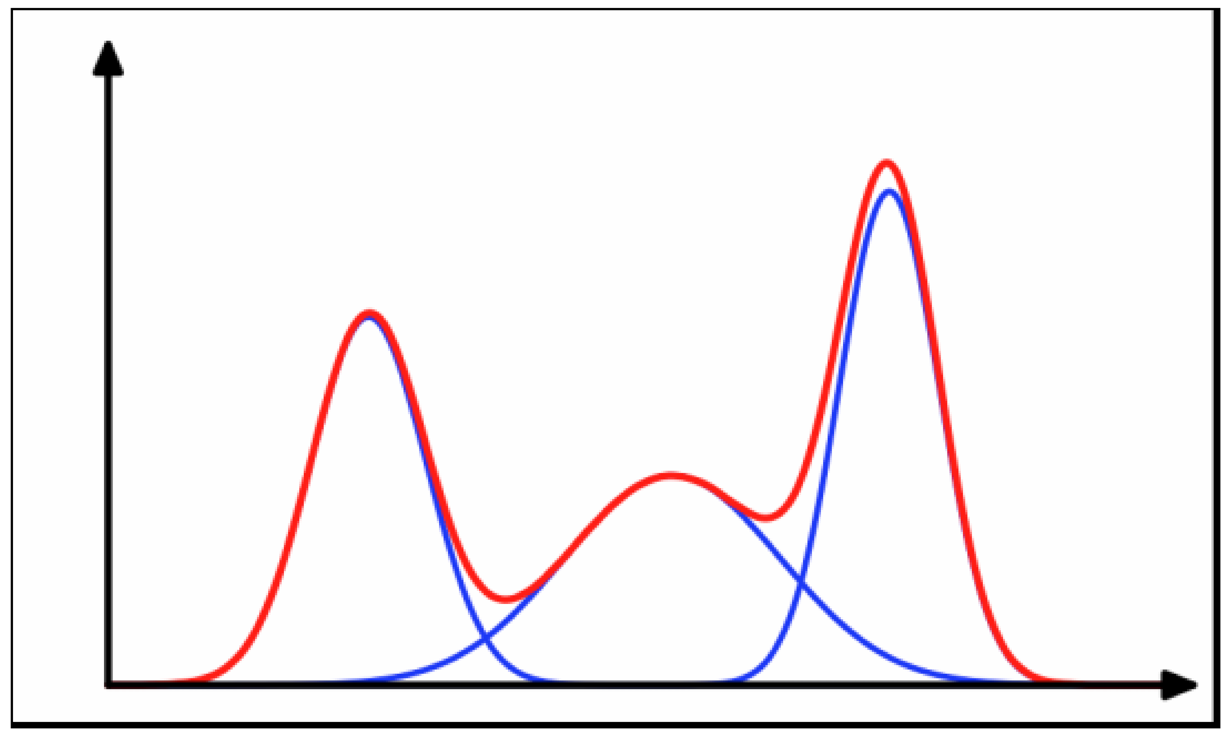

Figure 4: 1-D Gaussian Mixture (red) using three Gaussians of equal weight (blue)

Previous Studies:

Pattern recognition techniques have been used before on this same Waka3D data set to interpret a turbidite system (Zhao and Marfurt, 2014).

The same data set has also been used as an overview of multi-attribute facies classification tools, including four unsupervised and two supervised techniques (Zhao et al., 2015).

The Gaussian mixture model has been used to statistically characterize well data in order to evaluate the probability density functions of different lithologies and tie the well to a 3D seismic volume. Well data was first put through independent component analysis (ICA1 and ICA2), before generating a Gaussian mixture model (Figure 5). (Lubo et al., 2014)

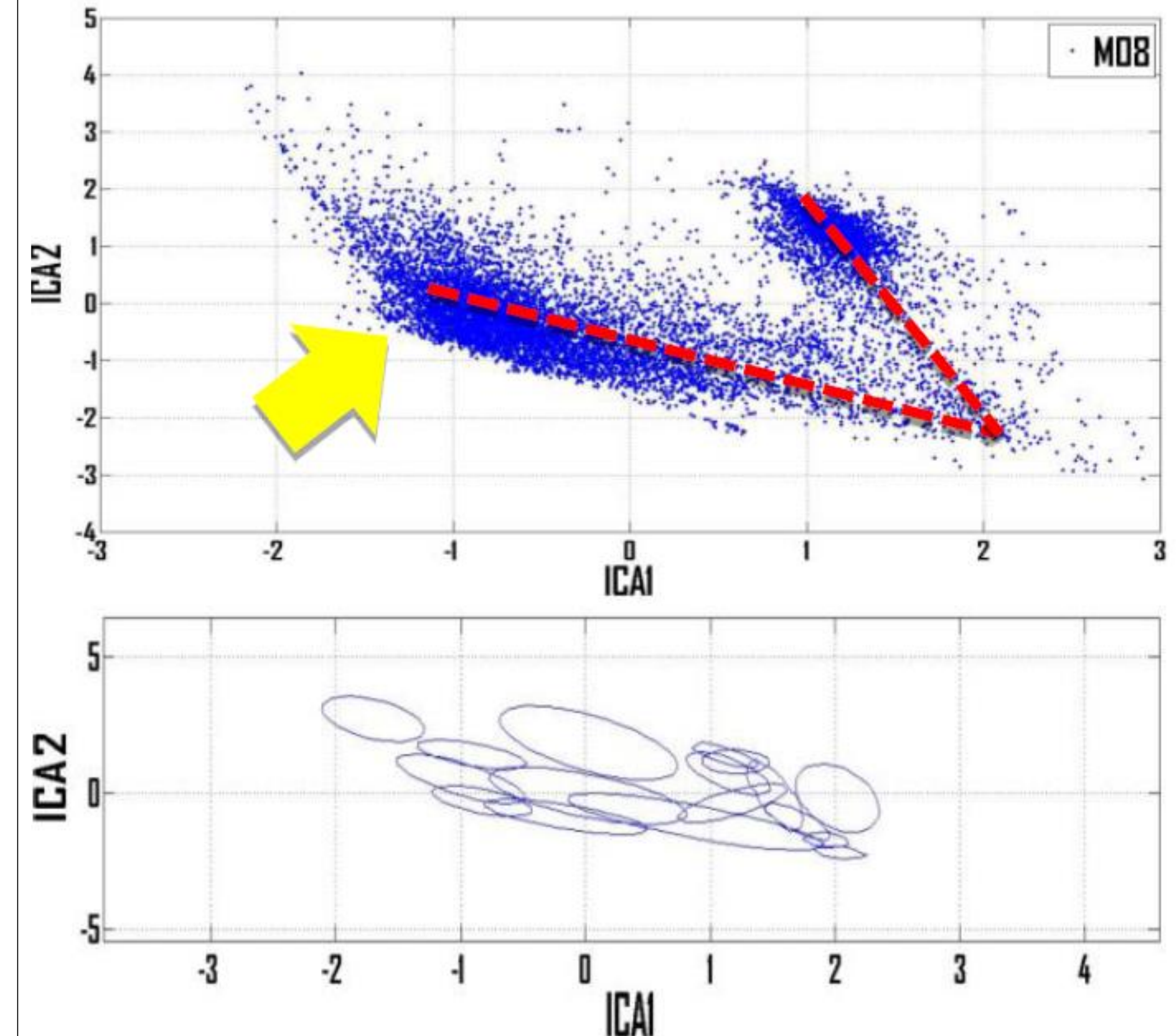

Figure 5: Top- scatter plot of well data. Bot- GMM

Plans for 2016:

Using the Waka 3D data set, generate a suite of attributes using AASPI. Attributes are then used as inputs for the GMM. Probabilistic seismic facies can then be generated by using the centroids of the Gaussians.

References

Lubo, D., K. Marfurt, and V. Jayaram, 2014, Statistical characterizationand geological correlation of wells using automatic learning Gaussian mixture models: Unconventional Resources Technology Conference, Extended Abstracts, 774–783.

Mitchell, J., Neil, H.L., 2012. OS20/20 Canterbury - Great South Basin: TAN1209 Voyage Report. National Institute of Water and Atmospheric Research Ltd (NIWA).

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