The promise of PROMISE

Michael Glinsky
SEPTCo
Jaap Leguijt
SIEP - RTS

Road map

- **overview of PROMISE algorithm**
- **utility of PROMISE algorithm**
  - Probabilistic Neural Network (PNN) trend curve regression
  - Amplitude Variation with Frequency (AVF) and AVO inversion
  - multiple model testing

Fundamentals of PROMISE algorithm

petrophysics (trend curves)

$P(m|d_{petro})$ = probability of model given petrophysical data

seismic

$q_{<n>}(n)$ = noise distribution

$= \exp(-\Sigma\, n_k^2 / <n_k>^2)$

$s(m)$ = synthetic seismic given model (forward modeling)

$d_{seismic}$ = seismic data

==> $P(d_{seismic}|m) = q_{<n>}(d-s(m))$ = probability of seismic given the model

$$P(m|d_{seismic},d_{petro}) \sim P(d_{seismic}\,|m)\;\; P(m|\,d_{petro})$$

Example of model (lithology) specification

$\mathbf{m} = (\ \text{depth},\ v_{p,sand},\ v_{p,mud},\ v_{s,sand},\ v_{s,mud},\ \rho_{mud},\ \varphi,\ \text{NtG},\ f_{oil},\ f_{brine}\ )$

$P(m|d_{petro}) =$

$v_{p,sand}(\text{depth})$	σ_{vps}
$v_{p,mud}(\text{depth})$	σ_{vpm}
$v_{s,sand}(v_{p,sand})$	σ_{vss}
$v_{s,mud}(v_{p,mud})$	σ_{vsm}
$\rho_{mud}(v_{p,mud})$	$\sigma_{\rho m}$
$\varphi(v_{p,sand})$	σ_{φ}

depth	σ_{depth}
NtG	σ_{NtG}
f_{oil}	σ_{oil}
f_{brine}	σ_{brine}

$f_{gas} = 1 - f_{oil} - f_{brine}$

$s(m) =$

Gassmann substitution for fluid effect
thickness average density, 1/bulk & 1/shear modulus

$\Longrightarrow \langle\rho\rangle, \langle v_s\rangle \ \& \ \langle v_p\rangle$

$\Longrightarrow$ L & M $\Longrightarrow$ synthetic seismic of model

Utility of PROMISE algorithm

- **advantages**
  - handles error and calculation of mean properly when cross-correlation and non-linear trends exist between model parameters
  - natural integration with:
    - Monte Carlo AVO modeling (SAVIOR)
    - trend curves for AVO inversion
    - PNN trend curve regression
    - AVF inversion
  - multiple model testing (geologic scenario comparison)

Utility of PROMISE algorithm

- **disadvantages**
  – Monte Carlo too slow for routine use in 3D (in 5 yrs. possible in 3D with faster computers)
  – DEPSIM needs to be IO engine (current link incomplete & complicated)
- **observation**
  – except for error estimate and stability of that estimate PROMISE (as it is being used) is moral equivalent of FLINT
    - linear inversion
    - average angle stack inversion (AVO)
    - note: error estimate is in FLINT code but is not currently output

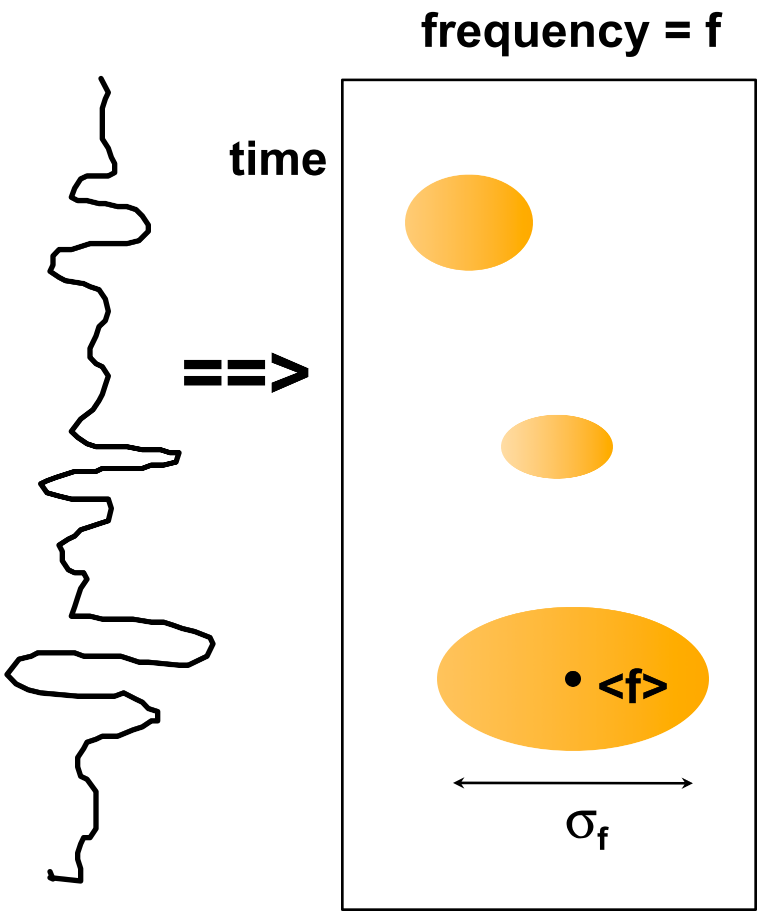
PNN trend curve regression

$P_{PNN}(m|d_{petro})$ = posterior probability of m given petrophysical data

<u>fundamental output of probabilistic neural network</u>

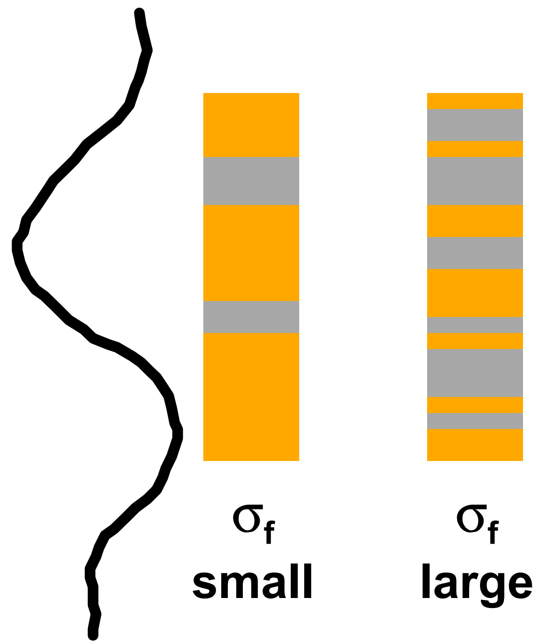
- **possible advantages**
  - weight data of different quality
    - poor vs. good logs
    - regional vs. prospect data
  - simplified addition of new data
  - more complicated forms of $P(m|d_{petro})$
- **QUESTION: Is there enough petrophysical data to support this mathematical formalism ??**

Amplitude Variation with Frequency inversion



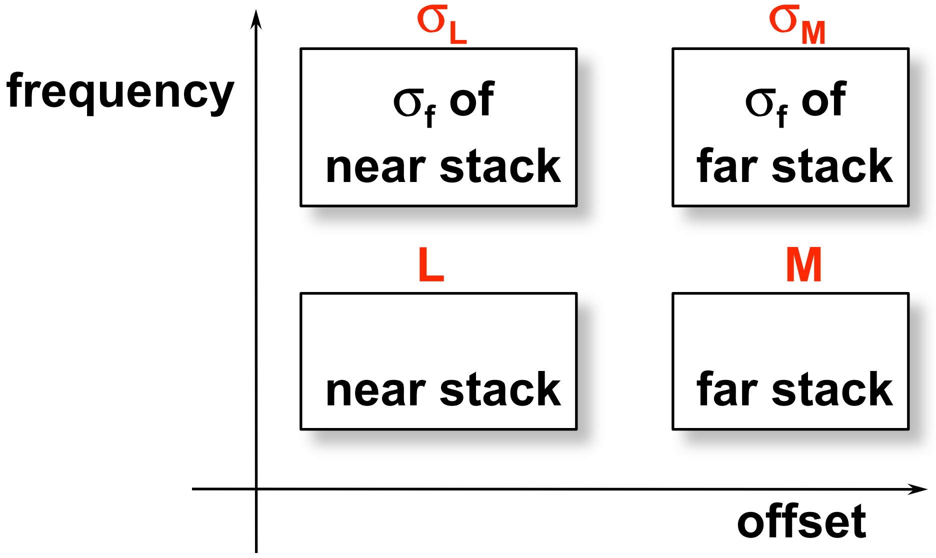
concept:

<f> and σ_f give information on statistics of lithology over seismic wavelet



O'Doherty and Anstey, Geo. Prosp. 19, 430 (1971)
Shapiro and Hubral, Geophysics 61, 1282 (1996)
S. Devi, SEPTCo, lithology estimation

AVF inversion could give independent constraints on model



Example of utility of AVF inversion

tell the difference between:

A. low NtG gas sand

B. high NtG oil sand