

Seismic Interferometry

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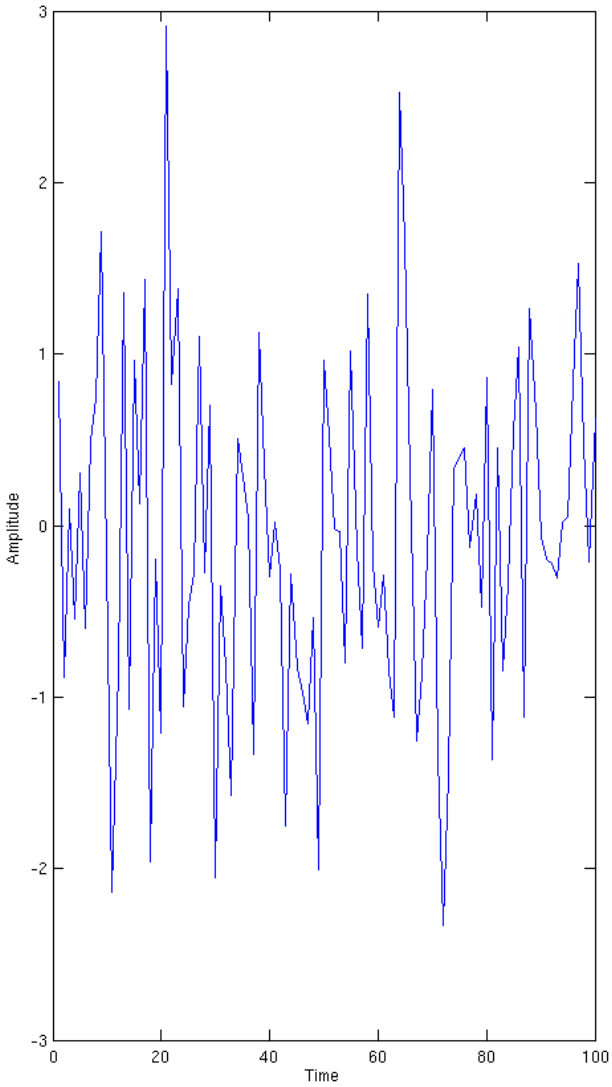
Definition of Interferometry

- Study of interference between signals to obtain information from the differences between them
- The interference is studied by taking the cross correlation of the signal pair
- Cross correlation estimates the degree to which series are correlated, using a sliding dot product to distinguish a distinct feature from a signal record
- Essentially slides one signal relative to the other

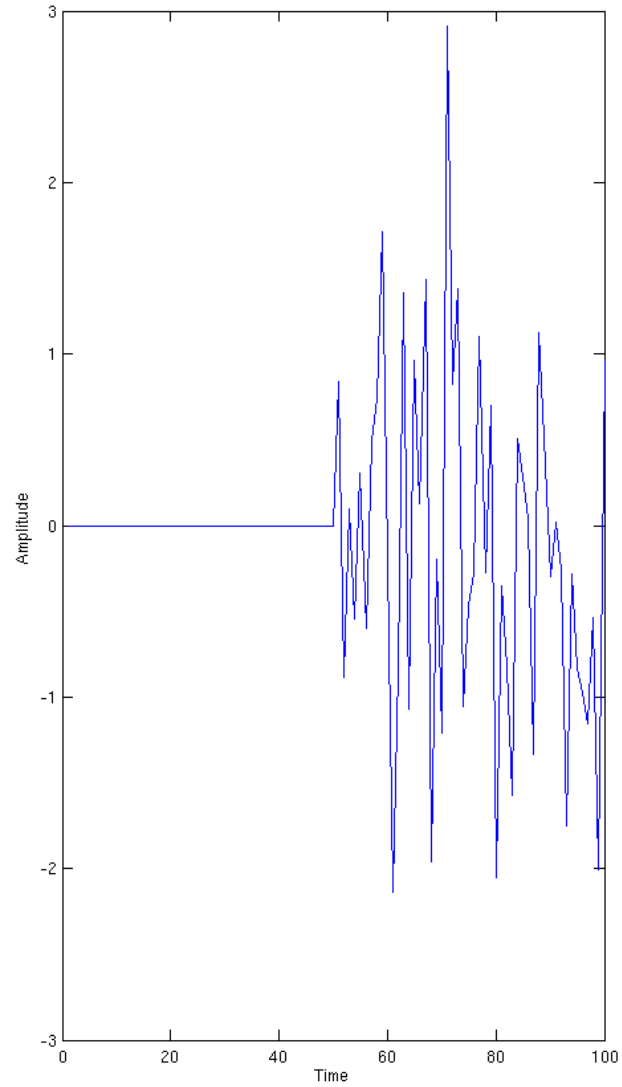
$$(f \star g)(t) \stackrel{\text{def}}{=} \int_{-\infty}^{\infty} f^*(\tau) g(t + \tau) d\tau,$$

Example of Cross Correlation

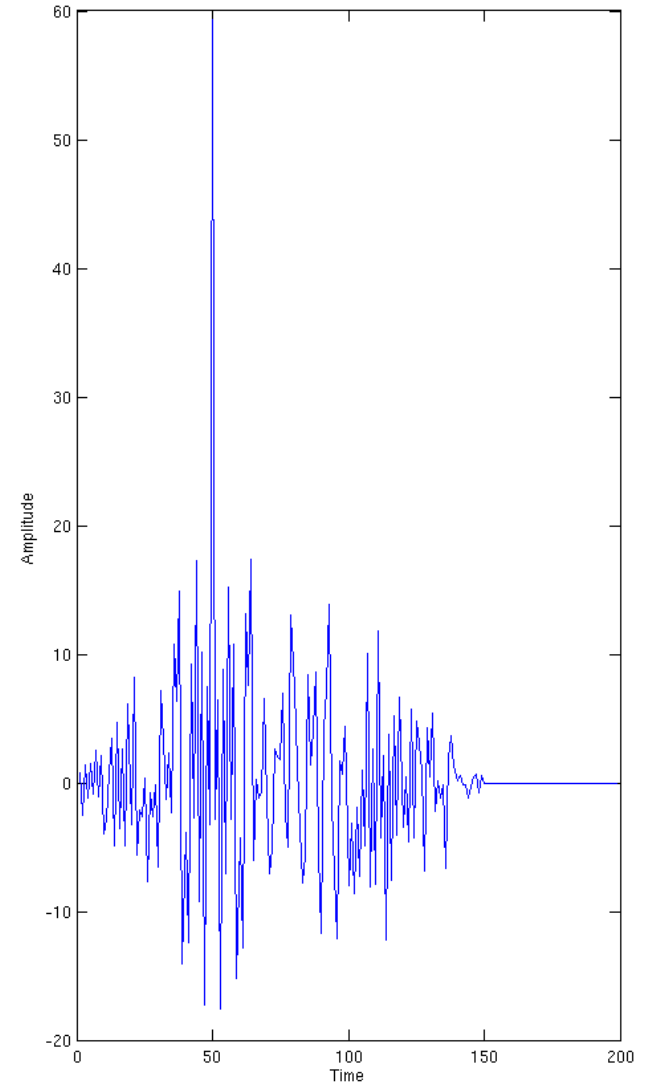
Base Signal



Delayed Signal



Cross Correlation



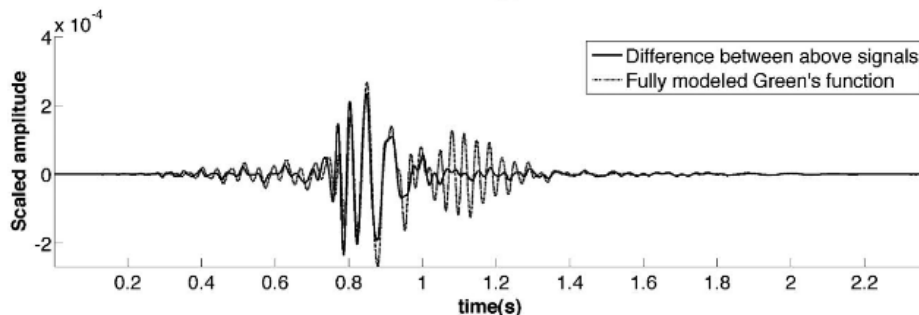
Development of Interferometry

- Claerbout Conjecture (1968) → Cross correlation of noise traces returns the response as if one of the locations is a virtual source
- Long time average of random noise yields the impulse response
- Allows construction of artificial seismic sources
- Requirements:
 - 1) Lossless media
 - 2) Diffuse, random noise

Interferometry in Use

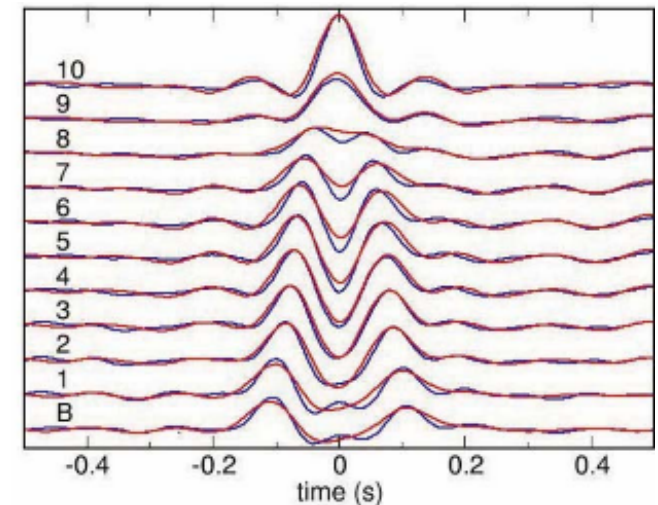
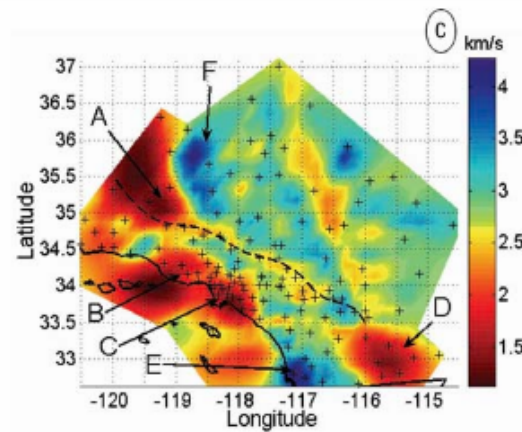
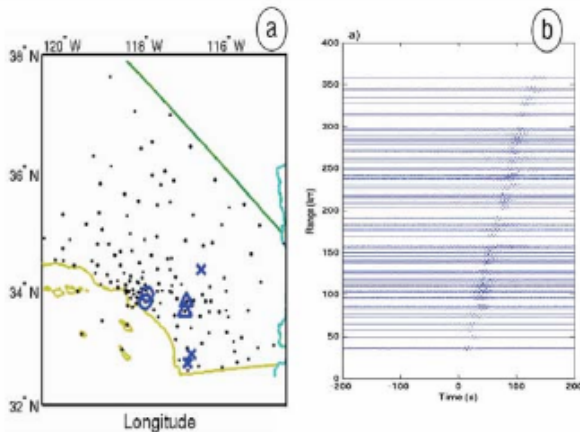
- Energy Sources:
Random or artificial
- Location of source not needed
- Allows approximation of impulse response as if a given receiver was the source
- Background noise to reconstruct surface and direct waves

- Practical Example:
Ground Roll removal-
Impulse response dominated by surface wave train-
Reproduced and subtracted using shallow, virtual source



Interferometry in Use

- Passive listening:
Cross-correlation of long noise records allows reconstruction of surface wave group velocity map
- Building Response:
Reconstruction of coherent shear wave impulse response to examine velocity and attenuation in building



Future

- Promising theoretical development and examples
- Challenge to extend theory to real world media (not lossless) and noise
- Correction for imperfect noise sources
- New theory development for deconvolution
- Future applications in time lapse seismic monitoring of changing reservoir conditions