Multicomponent imaging with Distributed Acoustic Sensing

Ivan Lim Chen Ning & Paul Sava

Center for Wave Phenomena, Colorado School of Mines
Multicomponent Imaging with Distributed Acoustic Sensing
The Golden Touch

Disney, 1935
6 components

\[ \varepsilon_{xx} \]

\[ \varepsilon_{xy} \]

\[ \varepsilon_{xz} \]

\[ \varepsilon_{yy} \]

\[ \varepsilon_{yz} \]

\[ \varepsilon_{zz} \]
equation of motion

$$\rho \ddot{u} - \nabla \cdot \sigma = f$$

stress-strain relation

$$-\sigma + \underline{c} : \varepsilon = h$$

\[ u = \text{displacement} \]
\[ \sigma = \text{stress tensor} \]
\[ \rho = \text{density} \]
\[ \underline{c} = \text{stiffness tensor} \]
equation of motion

$$\rho \ddot{\mathbf{u}} - \nabla \cdot \mathbf{\sigma} = \mathbf{f}$$

stress-strain relation

$$-\mathbf{\sigma} + \mathbf{c} : \mathbf{\varepsilon} = \mathbf{h}$$

\textbf{f} = \text{volume force density}

\textbf{h} = \text{deformation density}
\[ \mathbf{V} = - \oint_{\partial \Omega} ds \ u \ast G^f \]

\(G^f\) = propagator with \(f\) source
\[ V = - \oint_{\partial \Omega} ds \left[ \sigma \ast G^f + u \ast G^h \right] \cdot n \]

(Ravasi and Curtis, 2013)

\[ G^f = \text{propagator with } f \text{ source} \]
\[ G^h = \text{propagator with } h \text{ source} \]
example
\[ \partial \Omega \]

- explosive source
- multicomponent receivers
Marmousi II example
$V_{P0} (\text{km/s})$

$V_{S0} (\text{km/s})$

$\epsilon$

$\delta$

$\nu$
• pressure sources

• multicomponent receivers
\[ l_E = \sum_{e,t} \left[ \rho \dot{U} \cdot \dot{V} + (\mathbf{c} \nabla \mathbf{U}) : \nabla \mathbf{V} \right] \]

(Rocha et al., 2017)

\( \mathbf{U} = \text{source wavefield} \quad \mathbf{c} = \text{stiffness tensor} \)

\( \mathbf{V} = \text{receiver wavefield} \quad \rho = \text{density} \)
$f, h$
$f, h$
$f, \ h$
extrapolation from the water layer
• pressure sources

• multicomponent receivers
f: OBS
f: streamer
take home message

MIDAS improves elastic seismic imaging
acknowledgment

Matteo Ravasi, Statoil

Daniel Rocha
MIDAS