An efficient interpolation for calculation of the response of composite layered material and its implementation in MUSIC imaging
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To build
- Accurate computational models of complex anisotropic multi-layer composite panels
- Robust, fast, end-user's friendly imaging procedures

Electromagnetic modeling and preliminary numerical results

Undamaged structure
- Each layer: homogeneous anisotropic (different e.m. properties from layer to layer)
- Uniaxial dielectric (glass-based) or conductive (graphite-based)
- Effective media large-scale hypothesis
- Diagonal tensor in eigenframes along and orthogonal to fibers' axes
- Dyadic Green function in need as well as response to known distributed electric source anywhere in the structure

Damaged structure
- E.M. parameters differ from background stratified panel within layers or at interfaces
- 3-D volumetric defects (voids, fluid-filled cavities, localized damaged zones, etc.), or delaminations (thin, air-type slabs)
- Method of Moments upon vector contrast-source integral formulations, or change of dyads via supplementary reflection/transmission

Constructing the spectral and spatial response of the laminate forward modeling

New recurrence relations based on the propagator matrix method [8]
- To efficiently calculate the spectral response of the laminate
- Capable of stably dealing with distributed source along z
- Much more efficient compared to the traditional Green's function method
- To numerically solve the state equation

\[
\begin{align*}
\frac{\partial}{\partial z} (\tilde{z} + \tilde{A} \tilde{z} + \tilde{f}(\tilde{z})) = c(\tilde{z}) \text{ containing the tangential components of the fields and } \tilde{f}(\tilde{z}) \text{ being the source term}
\end{align*}
\]

Multiple Signal Classification (MUSIC) imaging with anisotropic layered media

Interpolation and integration using the Padua points
- Alternative representation as self intersections and boundary contacts of the generating curve
- Goal is to compute the I-FT of fast oscillating spectrum in the k_x – k_y plane

\[
G(x, y) = \frac{1}{\pi^2} \int \int G(x_k, y_k) \delta(x_k(x) - x) \delta(y_k(y) - y) \, dx_k \, dy_k
\]

Dealing with fast oscillating integrals
- Interpolation of the non-oscillating part at the Padua points with Chebyshev's polynomial interpolant

\[
\epsilon_{0} \tilde{G}_{B}(\tilde{k}) = \sum_{i=0}^{N} \tilde{k}_{i} \tilde{T}_{i}(\tilde{k}) \tilde{T}_{i}(\tilde{k}) - 2 \tilde{k}_{0} \tilde{T}_{1}(\tilde{k}) \tilde{T}_{0}(\tilde{k})
\]

with weights \( \epsilon_{0} \tilde{k}_{i} \) computed using [4]
- Fourier transform of Chebyshev polynomials given by

\[
\tilde{T}_{i}(\tilde{k}) \exp(-\lambda \tilde{k}) \, d\tilde{k}
\]

are managed using [6] among other good options.

MUSIC images of anisotropic layered media affected by two defects

- A cross type antenna array with 5 antennas on each arm.
- Each antenna as transceivers with x and y polarizations.
- Two small inclusions of dimension of 0.1 \( \times \) 0.1 \( \times \) 0.1 m.

\[
\begin{align*}
\tilde{z}_{x} = \tilde{z}_{y} = \tilde{z}_{z} = (4.5 \times 0.2 \times 0.05 \times 0.05), \tilde{r}_{x} = 45^\circ \\
\tilde{z}_{x} = \tilde{z}_{y} = \tilde{z}_{z} = (2 \times 0.3 \times 0.1 \times 0.1), \tilde{r}_{z} = 60^\circ \\
\tilde{z}_{x} = \tilde{z}_{y} = \tilde{z}_{z} = (4.5 \times 0.2 \times 0.05 \times 0.05), \tilde{h}_{x} = 0.5 \tilde{z}_{x} \\
\tilde{z}_{x} = \tilde{z}_{y} = \tilde{z}_{z} = (0.2 \times 0.1 \times 0.05), \tilde{h}_{z} = 0.2 \tilde{z}_{z} \\
\end{align*}
\]

Conclusions & perspectives
- Numerical integration method based on Padua points is proposed to avoid directly interpolating on the fast oscillating function
- The approach is validated by comparison with configurations found in the literature