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14. ABSTRACT

Parallelization of existing high-order codes have been completed as proposed.
The parallel performance of our code is demonstrated in table 1: nearly perfect scaling is observed.
Parallelization of other solvers was alos achieved during this period, including for example, our high-order penetrable scattering solver. A complete description of the associated methods can be found in Refs. 3.-5.; the parallel performance of the codes is discussed in detail in reference 4.

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AFOSR contract F49620-01-1-0316

"Accurate Fourier Methods for Virtual Electromagnetics Testing"

Final Technical Report

Oscar P. Bruno, MathSys Inc.

February 19 2005

Objectives

The objectives of this effort, as stated in the grant proposal, are two-fold:

1. Parallelization of existing high-order surface-scattering codes for acoustic scattering from smooth scatterers.
2. Initial development of the geometry capability, with application to description of smooth and singular surfaces.

Report

Parallelization

Parallelization of existing high-order codes has been completed, as proposed. The parallel performance of our code is demonstrated in in Table 1 below: nearly perfect scaling is observed. Parallelization of other solvers was also achieved during this period, including,

# of processors	Computing time (sec)
1	792.83
2	408.89
4	205.47
8	105.00
16	56.01
32	31.22
64	17.35

Table 1: Parallel performance of the singular integrator.

for example, our high-order penetrable scattering solver. A complete description of the associated methods can be found in Refs. 3.—5.; the parallel performance of the codes is discussed in detail in reference 4.

High-order geometry-description

An overall method has been produced which, based on newly introduced methods for high order approximation of non-periodic functions by Fourier series via a continuation approach,

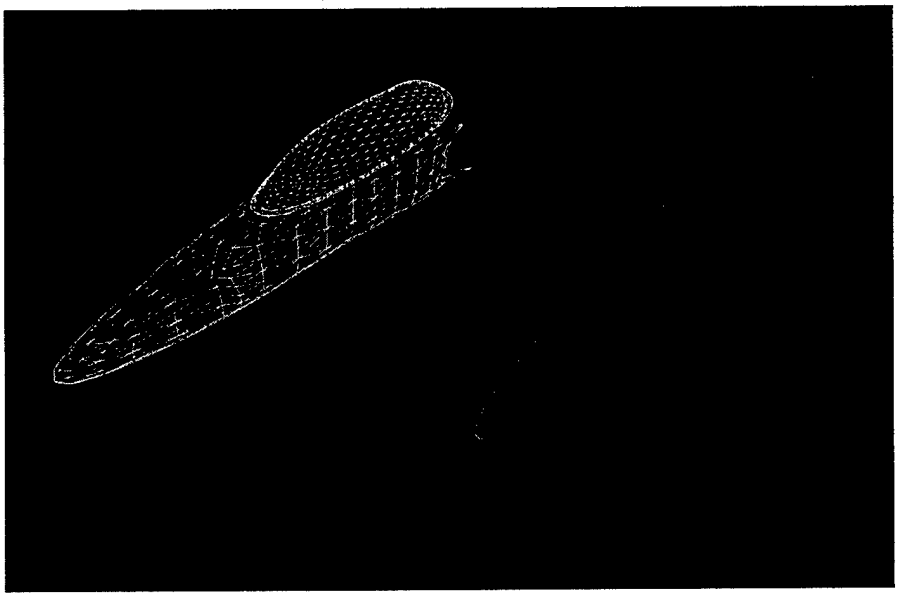

Figure 1: Upper left: Original triangulation. Bottom: Displays of four vector Fourier series functions obtained from the original triangulation. Upper right: Superimposed display of the four vector Fourier patches.

allows to produce highly accurate representation of large portions of air vehicles with very high accuracy. We demonstrate this in Figure 1, which shows the forward portion of an F-15 aircraft. In the figure we thus see the original triangulation (in white), displays of four Fourier series describing portions of the aircraft (bottom), and a display of the these four portions superimposed, producing, in fact, *explicit* Fourier series representations for the vehicle.

Personnel Supported

Dr. R. Paffenroth.

Publications

1. "Explicit and stable evolution of the generalized nonlinear Schrodinger equation", D. Amundsen and O. Bruno, submitted to IEEE Journal of Lightwave Technology.

2. "Pade time-stepping (PTS): a stable explicit scheme", D. Amundsen and O. Bruno, submitted to SIAM J. Sci. Comput.

3. "One-dimensional inverse scattering problem for optical coherence tomography", O. Bruno and J. Chaubell; To appear in Inverse Problems

4. "Higher-order Fourier approximation in scattering by two-dimensional, inhomogeneous media", O. Bruno and M. Hyde; To appear in *SIAM J. Numer. Anal.*

5. "A Fast, High-Order Method for Scattering by Penetrable Bodies in Three Dimensions", M. Hyde and O. Bruno; *J. Comput. Phys.* **202** 236–261 (2005).

6. "An efficient, preconditioned, high-order solver for scattering by two-dimensional, inhomogeneous media", O. Bruno and M. Hyde; *J. Comput. Phys.* **200** 670–694 (2004).

7. "A new high-order high-frequency integral equation method for the solution of scattering problems I: Single-scattering configurations", O. Bruno, C. Geuzaine, and F. Reitich, *The 20th Annual Review of Progress in Applied Computational Electromagnetics (ACES 2004), April 19-23, 2004 - Syracuse, NY*

8. "A new high-order high-frequency integral equation method for the solution of scattering problems II: Multiple-scattering configurations", O. Bruno, C. Geuzaine, and F. Reitich, *The 20th Annual Review of Progress in Applied Computational Electromagnetics (ACES 2004), April 19-23, 2004 - Syracuse, NY*

9. "Prescribed error tolerances within fixed computational times for scattering problems of arbitrarily high frequency: the convex case", O. Bruno, C. Geuzaine, J. Monro, and F. Reitich; Phil. Trans. Roy. Soc. London A, **362**, 629-645, 2004.

10. "A fast algorithm for the simulation of polycrystalline misfits II: martensitic transformations in three space dimensions", G. Goldsztein and O. Bruno; Proc. Roy. Soc. London, 03PA0117/1–03PA0117/18 (2004).

11. "Inverse scattering problem for optical coherence tomography", O. Bruno and J. Chaubell; Optics Letters. **28**, 2049–2051 (2003).

12. "Wave scattering by inhomogeneous media: efficient algorithms and applications", O. Bruno; Physica B **338**, 67-73, (2003).

13. "A fast high-order solver for problems of scattering by heterogeneous bodies", O. Bruno and A. Sei; IEEE Trans. Antenn. Propag. **51**, pp. 3142-3154 (2003).

14. "Fast, high-order, high-frequency integral methods for computational acoustics and electromagnetics", Topics in Computational Wave Propagation: Direct and Inverse Problems, Lecture notes in computational science and engineering, **31** 43–82. Springer Verlag, 2003.

Interactions/Transitions

Participation in a wide range of scientific meetings, interaction with university colleagues and seminars at universities, as well as seminars and consulting work for industrial parties are a regular part of our research efforts. Recent and forthcoming plenary lectures are listed in the section "Honors and awards" below; other meetings, presentations and interactions include work in connection with KLA tencor and JPL, participation in the IPAM workshop on inverse problems in life sciences, participation in the 20th annual review of progrees in applied computational electromagnetics, etc.

Honors/Awards

PI will be/was plenary speaker at the conferences

- "Future Directions in Applied Mathematics-International Conference on the occasion of Jean-Claude Nedelec's 60th Birthday" (Ecole Polytechnique, Paris, France.) June 18-21, 2003.
- "Third International Conference on Boundary Integral Methods: Theory and Applications" (University of Reading, London Mathematical Society). 14-18 September 2004.
- "XIV Congress on Numerical Methods and their Applications" (Bariloche, Argentina.) 8-11 November 2004.
- "7th International Conference on Mathematical and Numerical Aspects of Wave Propagation" (WAVES'05, Brown University, Rhode Island.) June 20-24, 2005.