

Report on FEM2012

The 11th International Workshop on Finite Elements for Microwave Engineering – FEM2012 was held from June 4-6, 2012, in Estes Park, Colorado, USA. It was organized by Colorado State University (CSU), Fort Collins. The FEM international workshops are highly focused biannual events, providing an ideal meeting place for researchers who are active in either the theoretical and numerical development of finite-element and hybrid methods, or their application to a broad range of electromagnetic problems. Previous workshops were held in Sienna, Italy, in 1992 and 1994; Poitiers, France, in 1998; Boston, Massachusetts, USA, in 2000; Chios, Greece, in 2002; Madrid, Spain, in 2004; Stellenbosch, South Africa, in 2006; Bonn, Germany, in 2008; and Meredith, New Hampshire, USA, in 2010.

At FEM2012, we had about 100 attendees (Figure 1), equally split between US and non-US participation. Thirteen countries were represented: Austria, Canada, China, France, Germany, Italy, Poland, Serbia, South Africa, Spain, Sweden, Turkey, and United States. The delegates came to Estes Park from 47 cities and towns on four continents.

The workshop took place in the Stanley Hotel (Figure 2), a historic landmark hotel in a spectacular mountain-view location, offering old-world charm within the sight of the Rocky Mountain National Park. Located in Estes Park (Figure 3), one of the most beautiful resort towns in the US (an hour from Fort Collins, and an hour and one-half from Denver International Airport), the hotel was built in 1907-1909 by F. O. Stanley, the inventor (in 1897) of the Stanley Steamer automobile (on display in the hotel lobby). It inspired Stephen King to write *The Shining*, and served as a location site for several movies (including some of my favorites, such as “Dumb and Dumber”).

It hosted many US Presidents, royalties, and celebrities. Many believe that the hotel is haunted (the most cases of ghostly activity were reported for the MacGregor Ballroom, in which we had our conference banquet).

The FEM2012 Technical Program combined 82 papers organized in 12 special sessions, as follows (the session organizers, who did a wonderful job in securing top-quality papers and most reputable presenters, and also served as session chairs, are given in parentheses):

- S1 “Modeling and Design of Antennas and Arrays Using FEM”
(R. Kindt, D. Filipovic, E. Topsakal)
- S2 “Discontinuous Galerkin Methods”
(Q. H. Liu, W. Cai)
- S3 “Time-Domain FEM and Applications”
(D. White, O. Biro, T. Rylander)
- S4 “FEM and CEM Applications in Optics and Nanophotonics”
(E. Simsek)
- S5 “Model-Order Reduction Techniques”
(R. Dyczij-Edlinger, V. de la Rubia)
- S6 “Advances in Vector Bases for CEM”
(R. Graglia, A. Peterson, D. Wilton)
- S7 “FETD Modeling of Complex Media and Structures”
(R. Lee, F. Teixeira)



Figure 1. Participants of the 11th International Workshop on Finite Elements for Microwave Engineering (FEM2012) are seen here working hard on increasing their red blood-cell counts at 12,183 ft (3,713 m) above the sea level, during their trip to the nearby Rocky Mountain National Park. This was on the third day of the workshop. Practically all participants were AP-S members.



Figure 2. FEM2012 was held in the Historic Stanley Hotel (famous for Stephen King’s *The Shining*), located at an elevation of 7,500 ft (2,286 m) in Estes Park, Colorado. Standing in the front is Milan Ilić, FEM2012 Technical Program Committee Chair.



Figure 4. The FEM2012 session on “Modeling and Design of Antennas and Arrays Using FEM,” in the Billiard Room of the Stanley Hotel on the morning of June 4, 2012. Mr. F. O. Stanley was reported to have been periodically seen in this room. We had great attendance, equally split between the two conference rooms during the entire workshop.



Figure 3. FEM2012 attendees are shown ready for an evening walk in Estes Park, on June 5, 2012 (l-r) Jianming Jin, Andy Peterson, Marinos Vouvakis, B. Shanker, Rob Lee, Branislav Notaroš, Eric Lucas, Joanne Wilton, Don Wilton, Milan Ilić, and Olivera Notaroš.



Figure 5. The FEM2012 session on “Discontinuous Galerkin Methods” in Stanley’s Music Room, going on in parallel with the session in Figure 4. This room had the original piano that was played on several occasions by famous American composer and conductor John Philip Sousa (“The Stars and Stripes Forever”); it was also reported to play on its own.

- S8 “Adaptive FEM, Higher-Order Bases, and Advanced FEM Formulations”
(J. Webb, M. Gavrilovic, M. Salazar Palma, L. Garcia-Castillo)
- S9 “Advances in Hybrid Methods and Multiphysics Problems”
(B. Shanker, L. Kempel)
- S10 “FEM Modeling and Applications of Metamaterials and Periodic Media”
(K. Sertel, J. Volakis)
- S11 “Domain-Decomposition Methods”
(J.-F. Lee, Z. Peng)
- S12 “Advanced FEM/MoM Modeling, Design, and Optimization”
(C. J. Reddy, U. Jakobus, J. Zapata, J. Gil, D. Jiao, A. Cangellaris)

The talks ran in two parallel tracks in the historic Billiard Room (Figure 4) and the elegant Music Room (Figure 5), in two completely packed conference days, June 4 and 5, 2012. One track was predominantly dedicated to novel finite-element and hybrid methods, including sessions on vector basis functions, higher-order elements, domain-decomposition methods, discontinuous Galerkin methods, adaptive FEM, hybrid formulations for multiphysics problems, and model-order reduction techniques. The other track mostly covered a variety of cutting-edge applications of FEM and related computational techniques, including FEM modeling and design of antennas and arrays, metamaterials and periodic media, time-domain modeling of complex media and structures, applications in optics and nanophotonics, and optimization techniques. We had great and uniform attendance at all talks in both rooms. The FEM2012 *Book of Abstracts* is available electronically at <http://www.engr.colostate.edu/FEM2012>.

As a new feature, FEM2012 introduced the following series of open-forum discussions. These were moderated by leading FEM researchers and practitioners from academia, industry, and government, and held on the afternoon of the third day of the workshop, June 6, 2012:



Figure 6. A novelty of FEM2012 was a series of three open-forum discussions on the last afternoon (after our trip in Figure 1). The discussion on “FEM and CEM Bases, Elements, and Formulations” was moderated by Jon Webb, Andy Peterson, and Don Wilton.



Figure 7. However, as always, the best pieces of one-on-one discussion took place during the breaks, over cookies and coffee/tea in the Piñon Room, or in the main lobby of Stanley (see the Stanley Steamer in the back), as well as on the veranda outside.



Figure 8. The ten student winners of the newly established FEM2012 Student Paper Competition received student travel support grants sponsored by the US Army Research Office and were recognized at the conference banquet: (from second left to second-to-the last on the right) Thomas Bauernfeind, Stylianos Dosopoulos, Grzegorz Fotyga, Qing He, Gergely Koczka, Ana Manić, Safa Salman, Nada Šekeljić, Ming-Feng Xue, and Wang Yao. On the left is Jianming Jin and on the right is Branimir Notaroš, FEM2012 General Chairs.



Figure 9. A battle of the bands: the FEM2012 conference banquet was a very pleasant and entertaining event in spite of the workshop Chair’s long speech and his repeated attempts to be funny. The success was thanks to the great playing by the Fort Collins Jazz and Blues Band, led by Tony DeNardo. Reportedly, the Stanley Hotel’s ghosts (who you of course can’t see in this picture) were the only ones dancing during the official banquet and laughing at workshop Chair’s jokes (however, the dancing floor “exploded” afterwards).



Figure 10. Olivera Notaroš, an ECE faculty member at Colorado State University, headed the FEM2012 Local Organizing Committee, shown here.



Figure 11. The FEM2012 welcome reception on the evening of June 3, 2012, was a great opportunity to start conversations among old and new friends.



Figure 12. This is why our professional conferences are an invaluable and irreplaceable component of our building of research agendas, awareness, teams, and professional friendships. Shown are lively exchange of ideas over a lunch in Stanley's MacGregor Ballroom. Two past AP-S Presidents and a number of future presidents can be seen in the picture.

- D1 "Open Forum Discussion on FEM and CEM Bases, Elements, and Formulations"
(Moderators: A. Peterson, D. Wilton, J. Webb, K. Sertel)
- D2 "Open Forum Discussion on DDM, MOR, and Efficient FEM and Hybrid Solutions"
(Moderators: J.-F. Lee, Z. Peng, R. Dyczij-Edlinger, V. de la Rubia)
- D3 "Open Forum Discussion on FEM-Based Modeling, Design, and Applications"
(Moderators: L. Kempel, B. Shanker, R. Kindt, C.J. Reddy, K. Zhao, T. Euler)

We had a completely full room for these discussions (Figure 6), which turned out to be extremely useful and engaging. Many colleagues said that they had not seen open-forum discussions like these at any of our professional conferences. However, everyone thought that they were a great idea because one had a lot more discussion than at regular paper presentations, and everyone wanted to keep them for future FEM workshops. Of course, nothing surpasses one-on-one discussions during breaks (Figure 7) and social events.

The first open forum featured a very lively and detailed discussion in response to two main questions posed by the moderators: "Higher-order bases: do we need them? If so, why aren't they more widely used?" and "Special elements (singular basis functions, basis functions incorporating plane waves, etc.) are widely used in disciplines like mechanics; why aren't they being more widely proposed for computational electromagnetics (CEM)?" One of the common threads of the entire discussion may be expressed as follows. Academics want to explore new ideas (such as higher-order basis functions), whereas commercial software companies want to be able to assume that their users need to know almost nothing to use the software.

The second forum discussed such domain-decomposition methods as "divide-and-conquer" approaches. The discontinuous Galerkin technique was pointed out as an enabling technology for the use of the best solver for each part of the problem. Model-order-reduction approaches were identified as smart ways to recover the minimal information necessary to describe an electromagnetic system.



Figure 13. FEM conversations to the very end: FEM2012 was closed with the chuck-wagon dinner and cowboy show in the Elkhorn Lodge on June 6, 2012. This was a true Old West setting, including rustic metal plates (such as the one held by Roman Dyczij-Edlinger in the picture), in the oldest continually occupied structure in Colorado.



Figure 15. A visit to the Continental Divide, the un-drawn line traversing all of the Americas to separate drainages to the Atlantic and the Pacific. Branislav Notaroš is shown pointing to the Cache la Poudre Creek, which eventually joins the Missouri and Mississippi Rivers and reaches the Gulf of Mexico. Robert Kotiuga is pointing to the start of the mighty Colorado River, which makes the Grand Canyon on its way west to the Gulf of California.



Figure 14. FEM2012 participants are shown on the really spectacular tour of Rocky Mountain National Park, one of the oldest and most visited national parks in the US, on June 6, 2012. This was a narrated bus ride along the Trail Ridge Road, which is the highest continuous motorway in the US. All technical sessions were completed, all was well, and everyone seemed to be happy and sound, so the workshop Chair could finally relax for a nice snooze on the bus.



Figure 16. FEM2012 participants are shown using their conference gifts – binoculars (with engraved FEM2012 logos) – for a closer look at nearby mountain peaks, some reaching almost “14k” (thousand feet): (front) Luis Garcia-Castillo, Valentin de la Rubia, Milica Notaroš, and Jelena Notaroš; (back) B. Shanker, Jasmine Lee, Jin-Fa Lee, Marinos Vouvakis, and Andy Peterson.



Figure 17. Shown feeling like on the top of the world during their visit to the “Land Above the Trees,” with fascinating alpine tundra landscapes: (l-r) Joanne Wilton, Stylianos Dosopoulos, Milan Ilić, Branislav Notaroš, and Valentin de la Rubia. On the way back down, we saw some beautiful Rocky Mountain bighorn sheep, also called rams (the ram is the official mascot of CSU), elk, deer, and owls.



Figure 18. The trip culminated with a picnic lunch and a hike of the Roaring River (my absolutely most favorite spot in the park), displaying the equally magnificent and destructive power of nature. At 5:30 a.m. on July 15, 1982, the earthen Lawn Lake Dam at the top of the mountain collapsed, releasing a rushing 10 m-high flood wave downhill. A trash collector heard the crashing waters and alerted dozens of nearby campers, but unfortunately three campers did not succeed in climbing to safety.



Figure 19. Many of the “flying” boulders carried by the roaring flood wave on the morning of July 15, 1982, were much larger than a car. They are now deposited on the banks of the Roaring River. The picture shows FEM2012 attendees hiking the river banks: (standing) Nada Šekeljić, Nil Apaydin, Sanja Manić, Eric Lucas, Stylianos Dosopoulos, José Gil, and Ana Manić; (sitting on the top of a huge “flying” boulder) B. Shanker, Mahadevan Ganesh, and Marinos Vouvakis.

The third forum started with a discussion of FEM-based analysis and design relative to applications involving micro-scale, macro-scale, and multi-scale models, and rapidly grew into an extremely dynamic and useful exchange of ideas on future directions for the community. This included lots of good comments and suggestions by the attendees on how to revitalize CEM research and to renew student interest in the discipline; how to identify open problems of greatest practical and societal relevance, and approach them as the community in a concentrated synergistic research effort; and how to proactively promote and advertise our effort and agenda to funding agencies and other communities. The notes of the three open-forum discussions (taken by Andy Peterson, and then edited by several others) were later posted on the FEM2012 Web site, with an opportunity for the participants to add their comments in a blog fashion.

As another new feature, ten student winners of the FEM2012 Student Paper Competition received student travel support grants sponsored by the US Army Research Office. The student awardees, coming from several countries, presented their winning papers at the workshop, and were recognized at the conference banquet (Figures 8 and 9).

It is a great tradition of FEM International Workshops to provide extremely rich social programs for the delegates. The program prepared by the FEM2012 Local Organizing Committee (Figure 10) started with a welcome reception on the evening of June 3, 2012 (Figure 11). The program filled prac-

tically every hour of free time not used for paper sessions and open discussions during the following three days (Figure 12). Many workshop participants were delighted with the specially organized and guided Stanley Hotel Ghost & History Tours. These featured the beginnings of the hotel; the Stanley's most-haunted rooms; and places including Stephen King's room 217, where the creation of *The Shining* began; the underground tunnel; etc.

The FEM2012 closing reception on the evening of June 6, 2012 featured a unique western experience – a chuck-wagon dinner and cowboy show – at the Elkhorn Lodge & Ranch, Estes Park (Figure 13). The highlight of the social program was the trip to the Rocky Mountain National Park on June 6, 2012 (Figures 14-19). Because of the great interest, we had to introduce a second bus for the trip.

On behalf of all FEM2012 authors and participants, I would like to thank Jianming Jin, Milan Ilić, and Olivera Notaroš, whose help and support on the FEM2012 Organizing Committee were essential in all stages of the preparation and running of the workshop. Special thanks go to ANSYS (ANSOFT), CST (Computer Simulation Technology), and to EM Software & Systems SA (Pty.) Ltd. (FEKO). Thanks also to Colorado State University, the generous financial sponsorships from which enabled us to enrich the social program described in this report. The US Army Research Office is thanked for making the Student Paper Competition and Awards possible. The IEEE Antennas and Propagation Society, IEEE Microwave Theory and Techniques Society, URSI, and University of Illinois assisted with gracious technical sponsorships.

It was my great pleasure to be of service to the FEM and CEM community, to lead the organization of FEM2012, and to host so many great researchers and colleagues in Estes Park last summer. Many international attendees visited the US for the first time. Many US attendees visited Colorado for the first time. Almost all FEM2012 delegates visited Estes Park for the first time. To all: please visit again! I hope to see you all and many others at our next workshop, FEM2014, to be held in Chengdu, China.

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