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SDSC Joins Other UC San Diego Departments, LLNL in Oncology Collaboration

SCORE Project Pursues Novel High-Performance Computing Applications for Radiotherapy

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Researchers from the San Diego Supercomputer Center (SDSC) at UC San Diego have joined forces with the Department of Radiation Oncology in the university's School of Medicine, its Department of Mathematics, and the Lawrence Livermore National Laboratory (LLNL) in a three-year, $1.5 million project to pursue novel applications of high-performance computing (HPC) in radiotherapy.

Under the project, called SCORE for SuperComputing Online Re-planning Environment, SDSC researchers are collaborating with oncology researchers to redesign treatment plans leveraging HPC resources and expertise. The project was awarded from a University of California Office of the President grant based on the Lab Fees Research Program in 2009.

The ultimate goal of the proposed HPC-based radiation therapy, specifically referred to as 'Adaptive Radiation Therapy (ART) Based on High-Performance Computing,' is to deliver a prescribed radiation dose to targets containing tumors and cancerous regions, while sparing surrounding functional organs and normal tissues. Currently, these regions are treated using a so-called "optimal" treatment plan that is based on patient geometry acquired via imaging prior to commencement of a sequence of 25 to 40 daily treatments administered during a time span of five and eight weeks.

"This current treatment paradigm therefore implicitly assumes that the patient is static and ignores the fact that tumor and nearby organs are mobile and distensible, so that their position and shape may vary substantially from day to day, and that there is significant dynamic change in tumor geometry in response to the radiotherapy," said Steve Jiang, associate professor and executive director for the Center for Advanced Radiotherapy Technologies (CART), the research arm of the Department of Radiation and Oncology at UC San Diego's School of Medicine, and director of the SCORE project. "As a result, the quality of the current treatment plans may deteriorate during their course."

The biggest challenge for the proposed HPC-based radiation therapy is the real-time requirement of performing three computationally intensive tasks: patient modeling based on deformable image registration, radiation transport simulation and dose calculation using Monte Carlo methods, and treatment optimization as a large scale optimization problem.

"Traditional HPC platforms, due to the difficulty in availability to general clinical users and real-time accessibility, are not suitable for real-time re-planning treatment while the patient is lying under the treatment machine waiting for radiation treatment," said Amit Majumdar, head of the Scientific Computing Applications Group at SDSC, and a newly named associate professor in the Department of Radiation Oncology at UC San Diego's School of Medicine.

In the first phase of the project, the research group is exploring the use of graphics processing units (GPUs) as the parallel computing framework for real-time re-planning. Many of the algorithms and codes have been modified and implemented efficiently on GPUs. To date, this work has resulted in three peer-reviewed journal papers for CART, and additional submissions are under review.

The team's work is already receiving attention from the field of cancer therapy. "We now can perform a re-planning procedure within 10 seconds, while the current state of the art takes dozens of minutes," said Jiang. "Our work shows that online adaptive radiotherapy is possible, and that it has much promise as the next generation of technology for cancer radiotherapy, with great potential to improve local tumor control and reduce toxicities by adapting the treatment to the varying patient anatomy."

The research group is also focusing on developing a comprehensive prototype hardware and software environment integrating GPUs, radiotherapy codes, and clinically efficient graphical user interfaces (GUI) that medical professionals can use in a real clinical environment for patient treatment. Initially, this will be used for patient treatment in a research environment with potential for full clinical implementation in the near future.

Researchers, in addition to Jiang and Majumdar, include Dong Ju Choi, a senior computational scientist at SDSC and also a newly appointed assistant professor in the university's Department of Radiation Oncology, who along with Majumdar is involved in collaborating on the HPC part of the project. Marie-Anne Descalle's group at LLNL is providing expertise in Monte Carlo simulation of radiation transport and dose calculation. Mike Holst, from UC San Diego's Department of Mathematics, is collaborating in the development and implementation of the algorithms.

Also participating in this research are postdoctoral researchers Xuejun Gu, Chunhua Men, Xun Jia, Franck Vidal, and Oliver Fluck, all from the Department of Radiation Oncology at UC San Diego's School of Medicine; and undergraduate student Michael Folkerts from UC San Diego's Physics Department.

About SDSC As an organized research unit of UC San Diego, SDSC is a national leader in creating and providing cyberinfrastructure for data-intensive research. Cyberinfrastructure refers to an accessible and integrated network of computer-based resources and expertise, focused on accelerating scientific inquiry and discovery. SDSC recently doubled its size to 160,000 square feet with a new, energy-efficient building and data center extension, and is a founding member of TeraGrid, the nation's largest open-access scientific discovery infrastructure.

About CART The Center for Advanced Radiotherapy Technologies (CART) is the research arm of the Department of Radiation Oncology in UC San Diego's School of Medicine. CART is committed to innovating and clinically testing new technological approaches to radiation therapy. To accomplish this, research efforts are integrated from many scientific disciplines, including medicine, medical physics, engineering, mathematics, computer science, and biology, to translate technological innovations from the laboratory to the clinic. CART provides an infrastructure to promote strong and unique collaborations between investigators from various disciplines, resulting in a seamless adoption of new technologies into routine clinical practice.

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