A High-Performance and Energy-Efficient CT Reconstruction Algorithm for Big Data

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Problem

- X-ray Computed Tomography (CT) is a tool used for inspection and validation applications.
- CT creates a 3D approximation of an object from many 2D images.
- Unlike in medicine, our CT data is up to 1000x larger (Hundreds to Thousands of Gigabytes).
- CT computations can require hours to days to months to complete.
- Many times, cannot be done on a supercomputer.
- These algorithms require large amounts of electricity, potentially straining resources.
- Recasting CT as a Big Data problem impacts many scientific and industrial applications such as:
  - Non-Destructive Testing
  - Materials Characterizations
  - Quality Assurance
  - Verification and Validation

Approach

- Employ multiple Graphics Processors (GPUs) to handle Big Data and intense computing tasks.
- GPUs have been used in medical-CT; these approaches do not work efficiently on Big Data.
- Leverage unique GPU-specific hardware to mitigate inefficiencies.
- Intelligently manipulate data transfers to and from the GPU using multiple CPU threads (i.e. cores).
- Optimize data reading and writing to and from the hard drives on the system.

Results

Performance:

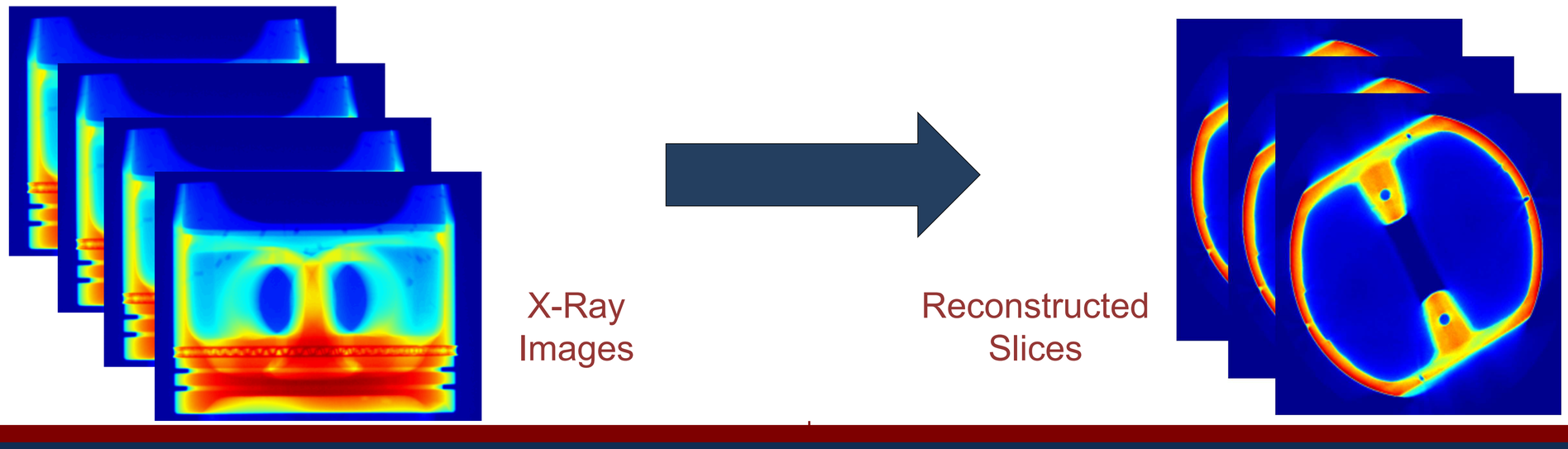
Algorithm	Time(hours)	Speedup	Energy(kWh)
CPU (Single-Thread)	45581	N/A	*
CPU (Multi-Thread)	2576	17.7x	1362.43
Medical 8 GPU	114.4	398.4x	164.34
SNL-Irregular 8 GPU	23.2	1964.7x	46.96
SNL-Modular 8 GPU	20	2779.1x	38.72

Scalability:

GPUs	SNL-Irregular	SNL-Modular	Medical
1	1x	1x	1x
2	1.87x	1.86x	*
4	3.29x	3.25x	*
6	4.38x	4.32x	1.72x
8	5.28x	4.96x	1.58x

Significance

- A five-year computation down to less than a day using a single workstation.
- Can run on a laptop to a scientific cluster.
- Potentially acquire and reconstruct unthinkably high-resolution CT volumes once the detector hardware capability is realized.
- Could provide tremendous insight into materials and fluids characterization.
- CT could be integrated as a regular quality control tool due to the fast reconstruction time.
- Algorithmic discoveries of this work could be applied to future Green Computing and Exascale efforts.
- Iterative reconstruction approaches for Industry can now be realized if an efficient forward model can be developed.



NNSA National Nuclear Security Administration
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