Pacific Northwest NATIONAL LABORATORY

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"No one has time to watch hours of video footage to find one particular frame. We are developing tables-of-content and index tables that allow the content contained in video data to be searched through and summarized–fast. A pair of eyeballs can only see so much; high-performance computers can see everything."

- Pacific Northwest National Laboratory Task Lead Harold Trease

U.S. DEPARTMENT OF ENERGY

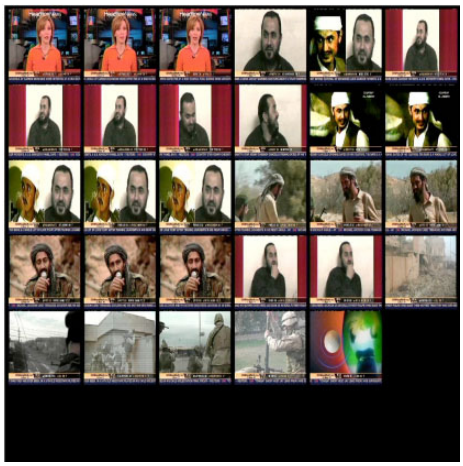
Center for Adaptive Supercomputing Software-Multithreaded Architectures (CASS-MT)

High-Throughput Video Processing and Content Analysis

Using the Cray XMT to search and summarize video archives

At a glance

Imagine the ability to scan hours of archived video footage in minutes to precisely pinpoint one thing. A person carrying a concealed weapon. A known criminal's face in a crowd. Relationships among presumed strangers. Researchers at Pacific Northwest National Laboratory (PNNL) are developing cutting-edge computer technology that can analyze massive amounts of video content to help protect our nation's security in foreign deserts and neighborhood streets.



The image summarizes the content of a news broadcast, where each frame characterizes the content of a group of frames. From this summarization we immediately get the gist of this news broadcast without having to watch it.

What we do

At PNNL's Center for Adaptive Supercomputing Software-Multithreaded Architectures (CASS-MT), researchers are working on algorithms to create searchable index tables that can be used to efficiently index, summarize, and access large quantities of video content. Having the ability to index and search the information contained within the videos, beyond the searching schemes of audio indexing and textual metadata tags, provides a mechanism to quickly extract and identify important content from image and video data.

By using the analogy of searching for a particular page in a book, a reader will typically flip to the table of contents or the index list to find a topic or keyword of interest. Much like a book, the PNNL researchers are constructing algorithms to generate two principal types of index tables for accessing video content.

Table of contents: Generating a time-based index captures the chronological flow that video data follows.

How we do it

The process used for creating both of these index tables is based on generating quantitative signatures from the information content of the video data. To do this, the videos are decomposed into frames, where the frames of data are decoded, converted, and the pixel data is extracted into memory. The frame-based video data is converted into high-dimensional signatures using statistical measures from the video pixel data. This process basically generates a digital "fingerprint" of the frame data based on its information content that can be stored and later accessed as a hash index. By taking the gradient of the signature data they can generate and sort the frames of a video (or videos) into the table-of-contents. A second index table is used to point from the entities contained within the video data back into the video.

Each frame of the video is decomposed into entities at various resolution levels. Not only is the signature stored, but also its original location in the original frames is stored so researchers can later point backward from the entity to the original segment and frame where the entity is found. Once the database of all entity signatures is constructed, they are filtered to remove duplicates and the unique entities are placed into a new database, called a dictionary. The entries in the dictionary represent a collection of unique signatures derived from the image data. The dictionaries are highly compressed, searchable, and indexable data structures that support fast lookup table searches.

Using the Cray XMT, these dictionaries are used to build data structures that map from "frames to entities" and "entities to frames" that form graph structures. From here, researchers can pinpoint where a face, or action, or object appears, and how often. The content analysis performed on the Cray XMT not only classifies the entities that researchers were seeking, but also shows entities of importance worth looking into.

Applications

Current Applications

- High-throughput video content analysis
- Searchable table-of-contents
- Entity classification

Future Applications

- Searchable entity index tables
- Classification and recognition algorithms

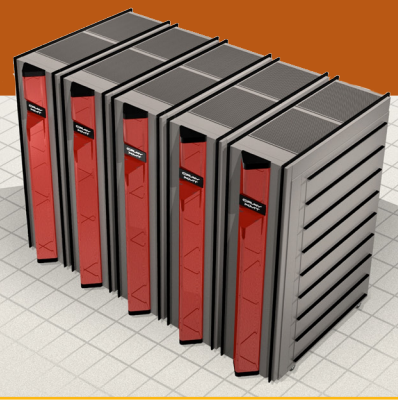
CASS-MT is dedicated to research on systems software, programming environments, and applications in a High-Performance Computing (HPC) multithreaded architecture environment.

We offer the only Open Science Cray XMT system, a one-of-a-kind supercomputer consisting of 128 multithreaded processors, 1 TB RAM, and a 7.7 TB Lustre parallel filesystem.

The Cray XMT supercomputer has the potential to substantially accelerate data analysis and predictive analytics beyond the limitations of traditional computing. Multithreaded processors allow multiple, simultaneous processing, helping researchers find solutions to the world's most complex challenges faster. The XMT can process irregular, data-intensive applications that have random memory access patterns. Unlike many applications where data delivery is dependent on memory speed, the Cray XMT's multi-threaded architecture tolerates memory access latencies by switching context between multiple threads that work continuously, overlapping the memory latency and preventing the processor from being held up while it waits for data to arrive.

The multithreaded technology powering our Cray XMT is ideally suited to perform pattern matching, scenario development, behavioral prediction, anomaly identification, and graph analysis.

Try it for yourself. We seek to create collaborations and provide expertise for porting and optimizing applications. The opportunity to use our Cray XMT system is available to internal and external research partners.



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