

manually download files associated with items, and place these files in a local store.

The client-server architecture enables users to:

- Subscribe and interpret multiple Data-casting feeds (same look and feel as a typical mail client),
- Maintain a list of all items within each feed,

- Enable filtering on the lists based on different metadata attributes contained within the feed (list will reference only data files of interest),
- Visualize the reference data and associated metadata,
- Download files referenced within the list, and
- Automatically download files as new items become available.

*This work was done by Andrew W. Bingham, Robert G. Deen, Kevin J. Hussey, Timothy M. Stough, Sean W. McCleese, and Nicholas T. Toole of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov).*

*This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at [danielb@caltech.edu](mailto:danielb@caltech.edu). Refer to NPO-47725.*

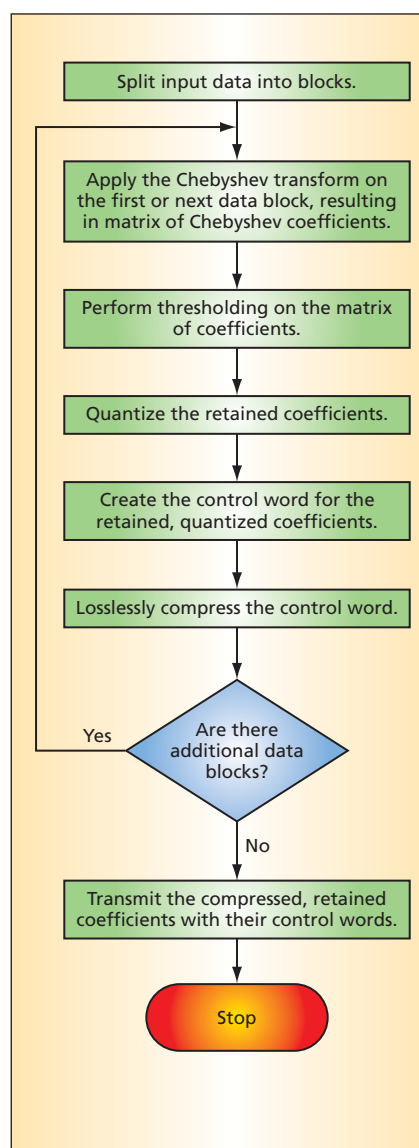
## Algorithm for Compressing Time-Series Data

This algorithm is generally applicable to many types of data.

Goddard Space Flight Center, Greenbelt, Maryland

An algorithm based on Chebyshev polynomials effects lossy compression of time-series data or other one-dimensional data streams (e.g., spectral data) that are arranged in blocks for sequential transmission. The algorithm was developed for use in transmitting data from spacecraft scientific instruments to Earth stations. In spite of its lossy nature, the algorithm preserves the information needed for scientific analysis. The algorithm is computationally simple, yet compresses data streams by factors much greater than two. The algorithm is not restricted to spacecraft or scientific uses: it is applicable to time-series data in general. The algorithm can also be applied to general multidimensional data that have been converted to time-series data, a typical example being image data acquired by raster scanning. However, unlike most prior image-data-compression algorithms, this algorithm neither depends on nor exploits the two-dimensional spatial correlations that are generally present in images.

In order to understand the essence of this compression algorithm, it is necessary to understand that the net effect of this algorithm and the associated decompression algorithm is to approximate the original stream of data as a sequence of finite series of Chebyshev polynomials. For the purpose of this algorithm, a block of data or interval of time for which a Chebyshev polynomial series is fitted to the original data is denoted a fitting interval. Chebyshev approximation has two properties that make it particularly effective for compressing serial data streams with minimal loss of scientific information: The errors associated with a Chebyshev approximation are nearly uniformly distributed over the fitting interval (this is



**Chebyshev Transforms** are calculated in this algorithm, which effects lossy compression of data. Parameters of the algorithm can be adjusted to balance accuracy versus degree of compression.

known in the art as the “equal error property”); and the maximum deviations of the fitted Chebyshev polynomial from the original data have the smallest possible values (this is known in the art as the “min-max property”).

The algorithm performs the same sequence of calculations on each successive data block (see figure). For each block, the first step is a calculation of a Chebyshev transform; that is, a matrix of coefficients of a Chebyshev series. This involves calculation of linear combinations of data samples with the applicable Chebyshev coefficients. The Chebyshev coefficients are fixed and known, making it possible to reduce the computational burden by computing them in advance, storing them in lookup tables, and retrieving them from the lookup tables as needed. In the next step, the matrix of coefficients is thresholded: only those coefficients larger than a threshold specified by the user are retained. The retained coefficients are then quantized to reduce their representations to no more than a number of bits specified by the user.

Next, there is generated a bit-control word, which is to be used during the subsequent decompression process to indicate the locations for insertion of the quantized retained coefficients and for insertion of place holders (zeroes) at locations of coefficients that are not retained. The bit-control word is then encoded by a lossless compression technique; this step can significantly increase the overall compression ratio without introducing additional loss. If there are more data blocks to be processed, then the process as described thus far is repeated for the next block. If there are no more blocks to be processed, the compressed data and their control words are transmitted.

The results obtained by use of the algorithm depend partly on three parameters: the block size (the number of data samples in a block), the aforementioned threshold value, and the aforementioned number of quantization bits. By adjusting the values of these parameters for different types of data, one can obtain usefully large compression ratios with minimal er-

rors. Higher threshold values always result in greater compression ratios at the expense of quality of reconstructed signals. Increasing numbers of quantization bits generally reduces compression ratios but yields reconstructed signals of higher quality. Increasing block sizes yields more-varied results; in general, larger compression ratios are associated with

larger blocks because fewer block maxima and minima are stored.

*This work was done by S. Edward Hawkins III and Edward Hugo Darlington of Johns Hopkins University Applied Physics Laboratory for Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-14820-1*

---

## Σ Onboard Science and Applications Algorithm for Hyperspectral Data Reduction

*NASA's Jet Propulsion Laboratory, Pasadena, California*

An onboard processing mission concept is under development for a possible Direct Broadcast capability for the HypsIRI mission, a Hyperspectral remote sensing mission under consideration for launch in the next decade. The concept would intelligently spectrally and spatially subsample the data as well as generate science products onboard to enable return of key rapid response science and applications information despite limited downlink bandwidth. This rapid data delivery concept focuses on wildfires and volcanoes as primary applications, but also has applications to vegetation, coastal flooding, dust, and snow/ice applications.

Operationally, the HypsIRI team would define a set of spatial regions of interest where specific algorithms would be executed. For example, known

coastal areas would have certain products or bands downlinked, ocean areas might have other bands downlinked, and during fire seasons other areas would be processed for active fire detections. Ground operations would automatically generate the mission plans specifying the highest priority tasks executable within onboard computation, setup, and data downlink constraints.

The spectral bands of the TIR (thermal infrared) instrument can accurately detect the thermal signature of fires and send down alerts, as well as the thermal and VSWIR (visible to short-wave infrared) data corresponding to the active fires. Active volcanism also produces a distinctive thermal signature that can be detected onboard to enable spatial subsampling. Onboard algorithms and ground-based algorithms suitable for on-

board deployment are mature. On HypsIRI, the algorithm would perform a table-driven temperature inversion from several spectral TIR bands, and then trigger downlink of the entire spectrum for each of the hot pixels identified.

Ocean and coastal applications include sea surface temperature (using a small spectral subset of TIR data, but requiring considerable ancillary data), and ocean color applications to track biological activity such as harmful algal blooms. Measuring surface water extent to track flooding is another rapid response product leveraging VSWIR spectral information.

*This work was done by Steve A. Chien, Ashley G. Davies, and Dorothy Silverman of Caltech for NASA's Jet Propulsion Laboratory, and Daniel Mandl of Goddard Space Flight Center. For more information, contact iaoffice@jpl.nasa.gov. NPO-47471*

---

## Σ Sampling Technique for Robust Odorant Detection Based on MIT RealNose Data

*NASA's Jet Propulsion Laboratory, Pasadena, California*

This technique enhances the detection capability of the autonomous RealNose system from MIT to detect odorants and their concentrations in noisy and transient environments. The low-cost, portable system with low power consumption will operate at high speed and is suited for unmanned and remotely operated long-life applications.

A deterministic mathematical model was developed to detect odorants and calculate their concentration in noisy environments. Real data from MIT's NanoNose was examined, from which a signal conditioning technique was proposed to enable robust odorant detec-

tion for the RealNose system. Its sensitivity can reach to sub-part-per-billion (sub-ppb).

A Space Invariant Independent Component Analysis (SPICA) algorithm was developed to deal with non-linear mixing that is an over-complete case, and it is used as a preprocessing step to recover the original odorant sources for detection. This approach, combined with the Cascade Error Projection (CEP) Neural Network algorithm, was used to perform odorant identification.

Signal conditioning is used to identify potential processing windows to enable robust detection for autonomous systems.

So far, the software has been developed and evaluated with current data sets provided by the MIT team. However, continuous data streams are made available where even the occurrence of a new odorant is unannounced and needs to be noticed by the system autonomously before its unambiguous detection. The challenge for the software is to be able to separate the potential valid signal from the odorant and from the noisy transition region when the odorant is just introduced.

*This work was done by Tuan A. Duong of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47488*