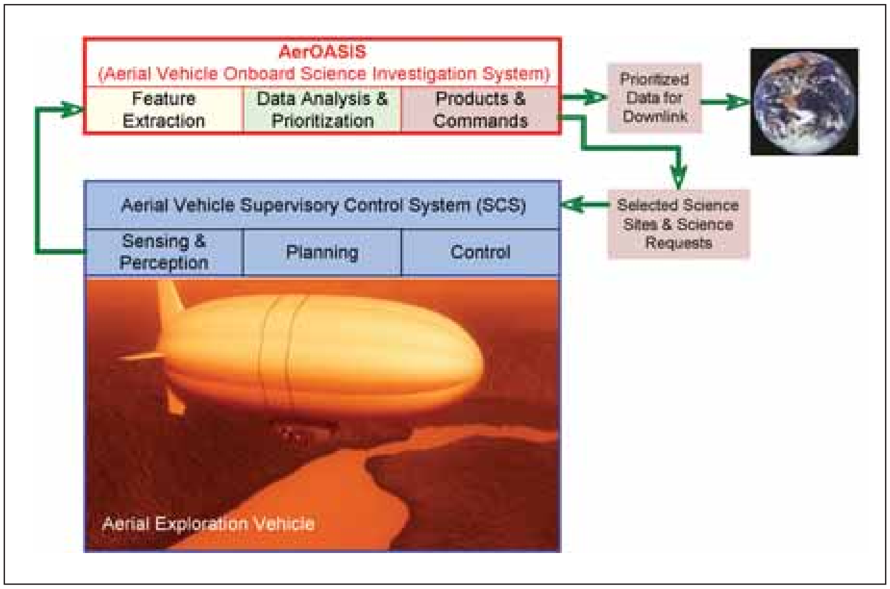


The **AerOASIS** provides a number of functions in airborne planetary exploration.

AerOASIS system is composed of three main subsystems: Feature Extraction, which processes sensor imagery and other types of data (such as atmospheric pressure, temperature, wind speeds, etc.) and performs data segmentation and feature extraction; Data Analysis and Prioritization, which matches the extracted feature vectors against scientist-defined signatures. The results are used to detect novelty, perform science data prioritization, and summarization for downlink, and identify and select high-value science sites for *in-situ* studies; and Planning and Scheduling, which generates operations plans to achieve observation requests submitted from Earth and from onboard data analysis. These science requests can include low-altitude, high-resolution surveys, *in-situ* sonde deployment, and/or surface sample acquisition for onboard analysis.

This work was done by Daniel M. Gaines, Tara A. Estlin, Steven R. Schaffer, and Caroline M. Chouinard of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact 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. Refer to NPO-46895.

Real-Time Exponential Curve Fits Using Discrete Calculus

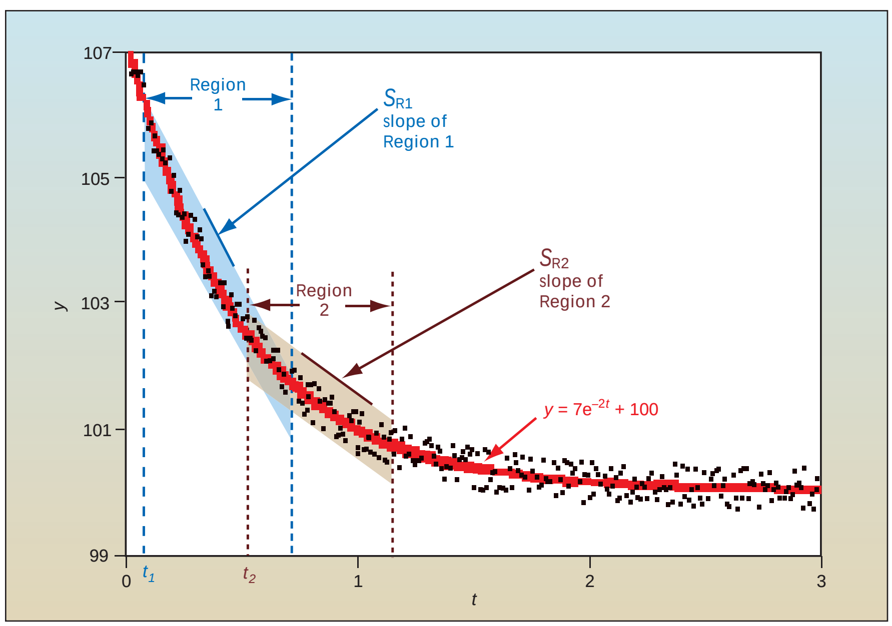
Novel curve fitting solution removes the limits, is robust, and is faster.

John F. Kennedy Space Center, Florida

An improved solution for curve fitting data to an exponential equation ($y = Ae^{Bt} + C$) has been developed. This improvement is in four areas — speed, stability, determinant processing time, and the removal of limits. The solution presented avoids iterative techniques and their stability errors by using three mathematical ideas: discrete calculus, a special relationship (between exponential curves and the Mean Value Theorem for Derivatives), and a simple linear curve fit algorithm. This method can also be applied to fitting data to the general power law equation $y = Ax^B + C$ and the general geometric growth equation $y = Ak^{Bt} + C$.

This improved method offers several advantages over prior exponential-curve-fitting methods. The advantages are as follows:

- Speed: Iterative (non-linear) methods are 50 to 100 times slower. Previously, only iterative methods could be used when C was not zero, or when all the samples were not zero or greater.
- Stability: No bad guesses. There is no chance of making a bad first guess as sometimes happens in iterative (non-linear) techniques. Sometimes the iterative techniques "blow up" when they start with a bad guess.
- Real-Time requires determinism: Being faster would allow this method to be used in real-time applications where non-linear methods take too much processing time. But, most real-time applications require determinism (a consistent processing time from



Two Regions of Points that overlap are shown. The slope ratios of these two regions are used in estimating *B*. In this example, $A = 7$, $B = -2$, and $C = 100$.

curve fit to curve fit, or at least a known maximum processing time). Iterative techniques vary greatly in the processing time they consume. This new method takes the same amount of processing time (for the same number of data points), no matter what the error distribution is. Iterative techniques sometimes only take 50 times longer and sometimes more than 100 times longer, depending on how the data varies and the initial guesses.

- y can cross zero: Even if $C = 0$, the non-iterative methods require all sample points to be zero or greater (or transformed to greater than zero). This method does not have any such limitation.

The improved method has a theoretical basis in discrete calculus, statistics, and regular calculus. The following description of the method omits most of the details of the theory for the sake of brevity.

The method is embodied in an algorithm for computing B in the equation $y = Ae^{Bt} + C$. Once B is known, typical linear methods can be used to solve for A and C. This method presents many ways to compute B. One way is by doing a linear (straight line) curve fit to two different regions in the data. The change in slope of these two regions gives us an estimate for B. The two different regions can even overlap each other to improve the curve fit. B is only dependent on the change in slope and the change in time.

Let S_{R1} be the slope calculated for Region 1 (see figure). Let S_{R2} be the slope calculated for Region 2. Then the change in slope can be estimated by S_{R1}/S_{R2}. The time used to cause this change in slope is equal to the time between the first samples in each region (if each region contains the same number of equally spaced points). It can be shown that:

$$B = \ln(S_{R1}/S_{R2})/(t_1 - t_2).$$

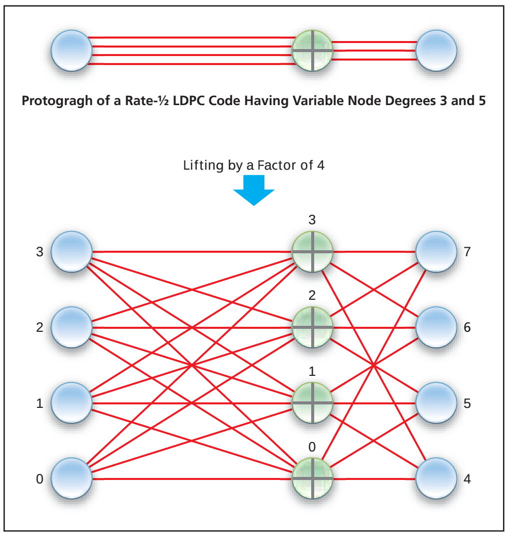
This work was done by Geoffrey Rowe of ASRC Aerospace Corp. for Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13153

Short-Block Protograph-Based LDPC Codes

Characteristics of these codes include low undetected-error rates and low latency.

NASA's Jet Propulsion Laboratory, Pasadena, California

Short-block low-density parity-check (LDPC) codes of a special type are intended to be especially well suited for potential applications that include transmission of command and control data, cellular telephony, data communications in wireless local area networks, and satellite data communications. [In general, LDPC codes belong to a class of error-correcting codes suitable for use in a variety of wireless data-communication systems that include noisy channels.] The codes of the present special type exhibit low error floors, low bit and frame error rates, and low latency (in comparison with related prior codes). These codes also achieve low maximum rate of undetected errors over all signal-to-noise ratios, without requiring the use of cyclic redundancy checks, which would significantly increase the overhead for short blocks. These codes have protograph representations; this is advantageous in that, for reasons that exceed the scope of this article, the applicability of protograph representations makes it possible to design high-speed iterative decoders that utilize belief-propagation algorithms.



Construction of a Code of the present special type includes elaboration of a starting protograph in a process denoted in the art as "lifting." In this example, a starting protograph is first lifted by a factor of 4. In a subsequent step (not shown in the figure), the lifted-by-4 protograph is further lifted by a factor of 16 using circulant permutations.

The codes of the present special type are characterized mainly by rate 1/2 and input block sizes of 64, 128, and 256 bits. To simplify encoder and decoder implementations for high-data-rate transmission, the structures of the codes are based on protographs (see figure) and circulants. These codes are designed for short blocks, the block sizes being based on maximizing minimum distances and stopping-set sizes subject to a constraint on the maximum variable node degree. In particular, these codes are designed to have variable node degrees between 3 and 5.

Short-block codes are desirable in communication systems in which frame-length constraints are imposed on the physical layers. For reasons that, once again, exceed the scope of this article, avoidance of degree-2 nodes enables construction of codes having minimum distance that grows linearly with block size. Limiting code design to the use of variable node degrees ≥3 is sufficient, but not necessary, for minimum distance to grow linearly with block size. Increasing the node degree leads to larger minimum distance, at the expense of smaller girth. Therefore, there is an engineering compromise between undetected-error-rate performance (which is improved by increasing minimum distance) and the degree of suboptimality of iterative decoders typically used (which is adversely affected by graph loops).

Codes of the present special type were found to perform well in computational simulations. For example, for a code of input block size of 64, constructed from the protograph in the figure with variable node degrees 3 and 5, the maximum undetected-error rate was found to be $<3 \times 10^{-5}$. This maximum was found to occur at a bit signal-to-noise ratio (SNR) of about 1.5, and the undetected-error rate was found to be smaller at SNRs both above and below 1.5, notably decreasing sharply with increasing SNR above 1.5.

This work was done by Dariush Divsalar, Samuel Dolinar, and Christopher Jones of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-45190