



Technology Focus: Data Acquisition

Computer Program Recognizes Patterns in Time-Series Data

NASA's Jet Propulsion Laboratory, Pasadena, California

A computer program recognizes selected patterns in time-series data like digitized samples of seismic or electro-physiological signals. The program implements an artificial neural network (ANN) and a set of N clocks for the purpose of determining whether N or more instances of a certain waveform, W , occur within a given time interval, T . The ANN must be trained to recognize W in the incoming stream of data. The first time the ANN recognizes W , it sets clock 1 to count down from T to

zero; the second time it recognizes W , it sets clock 2 to count down from T to zero, and so forth through the N th instance. On the $N + 1$ st instance, the cycle is repeated, starting with clock 1. If any clock has not reached zero when it is reset, then N instances of W have been detected within time T , and the program so indicates. The program can readily be encoded in a field-programmable gate array or an application-specific integrated circuit that could be used, for example, to detect

electroencephalographic or electrocardiographic waveforms indicative of epileptic seizures or heart attacks, respectively.

This program was written by Charles Hand of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30636.

Program for User-Friendly Management of Input and Output Data Sets

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A computer program manages large, hierarchical sets of input and output (I/O) parameters (typically, sequences of alphanumeric data) involved in computational simulations in a variety of technological disciplines. This program represents sets of parameters as structures coded in object-oriented but otherwise standard American National Standards Institute C language. Each structure contains a group of I/O parameters that "make sense" as a unit in the simulation program with which this program is used. The addition of options and/or elements to sets of parameters amounts to the addition of

new elements to data structures. By association of child data generated in response to a particular user input, a hierarchical ordering of input parameters can be achieved. Associated with child data structures are the creation and description mechanisms within the parent data structures. Child data structures can spawn further child data structures. In this program, the creation and representation of a sequence of data structures is effected by one line of code that looks for children of a sequence of structures until there are no more children to be found. A linked list of structures is created dy-

namically and is completely represented in the data structures themselves. Such hierarchical data presentation can guide users through otherwise complex setup procedures and it can be integrated within a variety of graphical representations.

This program was written by Gerhard Klimeck of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30835.

Noncoherent Tracking of a Source of a Data-Modulated Signal

Properties of the modulation would be exploited to determine direction-dependent phase differences.

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A proposed tracking receiver system containing three suitably positioned antenna elements and special signal-processing equipment would determine the direction of incidence of a microwave signal containing spread-spectrum digital data modulation. If the system were

to contain two sets of antenna elements separated by a known baseline, it could determine the location of the transmitter as the intersection of the lines of incidence on the two antennas. Such systems could be used for diverse purposes in outer space and on Earth, including

tracking astronauts and small robotic spacecraft working outside a spacecraft or space station, and locating cellular telephones from which distress calls have been made. The principle of operation does not require the transmission of a special identifying or distress signal

by the cellular telephone or other transmitter to be tracked; instead, the system could utilize the data signal routinely sent by the transmitter, provided that the signal had the characteristics needed for processing as described below.

In its simplest form, the system would include three microstrip-patch antennas positioned to define an isosceles right triangle and a Cartesian coordinate system as depicted in Figure 1. The element at the origin of coordinates would be termed the reference element. The antenna elements on the x and y axes would both be separated from the reference element by a distance of half a wavelength at the carrier frequency of the signal to be tracked.

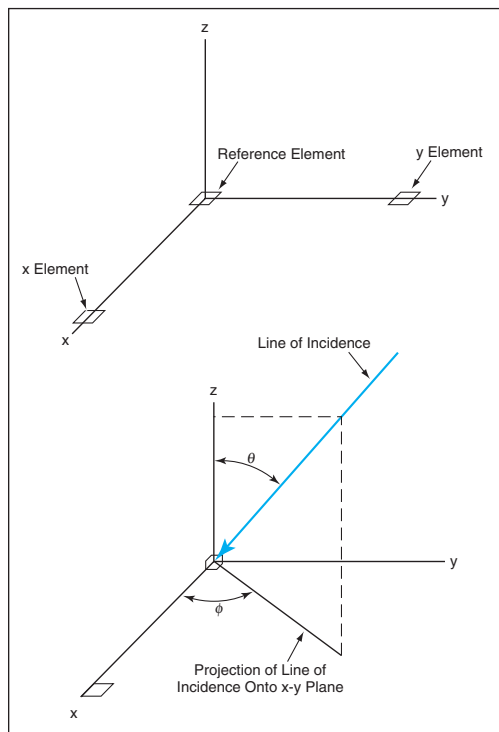


Figure 1. **Three Antenna Elements** would be positioned to define a coordinate system for measuring the angles, θ and ϕ , that specify the direction of incidence of a radio signal.

The basic equation for the phase of the incident signal can readily be manipulated to obtain the following equations for the colatitude (θ) and the azimuthal angle (ϕ) that specify the direction of incidence:

$$\theta = \arcsin \frac{(\Phi_1^2 + \Phi_2^2)^{1/2}}{\pi} \text{ and}$$

$$\phi = \arctan(\Phi_2/\Phi_1)$$

where Φ_1 is the difference between the signal phases at the x and reference antenna elements and Φ_2 is the corresponding phase difference for the y and reference elements. The tracking problem thus becomes one of determining Φ_1 and Φ_2 . In the presence of multipath interference and noise, the tracking problem is complicated by the need to compute a separate pair of phase differences and the corresponding direction for each path.

In a transmitter to be tracked by a preferred version of the proposed system, the baseband data to be conveyed would be orthogonally coded, then spread into two channels by use of two independent pseudonoise (PN) codes. The resulting baseband signals in the two channels would be used to modulate the microwave carrier signal by quaternary phase-shift keying (QPSK).

In the receiver (see Figure 2), the intermediate-frequency (IF) signals from the three antenna elements would be digitized, then processed through quadrature down-converters, then processed through fingers (defined in the next sentence) and combiners, the use of which would simplify the hardware needed to track the multipath components. As used

here, "finger" signifies a time-multiplexed functional block that enables (at the expense of memory) the use of the same circuitry to track the signals arriving on multiple paths. Each finger would manage its own spreading-sequence timing and would perform its own multipath acquisition and tracking, despreading, and maximum-likelihood detection of orthogonal symbols. The combiners would provide the appropriate delays to align the symbols from the fingers for addition.

The multipath components would be resolved and the phase differences needed to compute the direction to the transmitter would be determined in a signal-processing scheme, the complexity of which admits of only a brief summary here: The scheme would involve noncoherent demodulation; that is, it would not rely on the generation, in the receiver, of a reference signal coherent with the phase of the carrier signal. Instead, it would rely on aligning the phases of local (receiver) PN code generators with the phases the transmitter PN code generators. The scheme would involve correlations of received modulation symbols with each and every one of the possible orthogonal symbols (of which there would be a total of 64 in the preferred version).

This work was done by G. Dickey Arndt, Phong Ngo, Henry Chen, and Chau T. Phan of Johnson Space Center; Brent Hill of Modem Links, LLC; Brian Bourgeois of Antech; and John Duhl of Lockheed Martin. Further information is contained in a TSP (see page 1).

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23193.

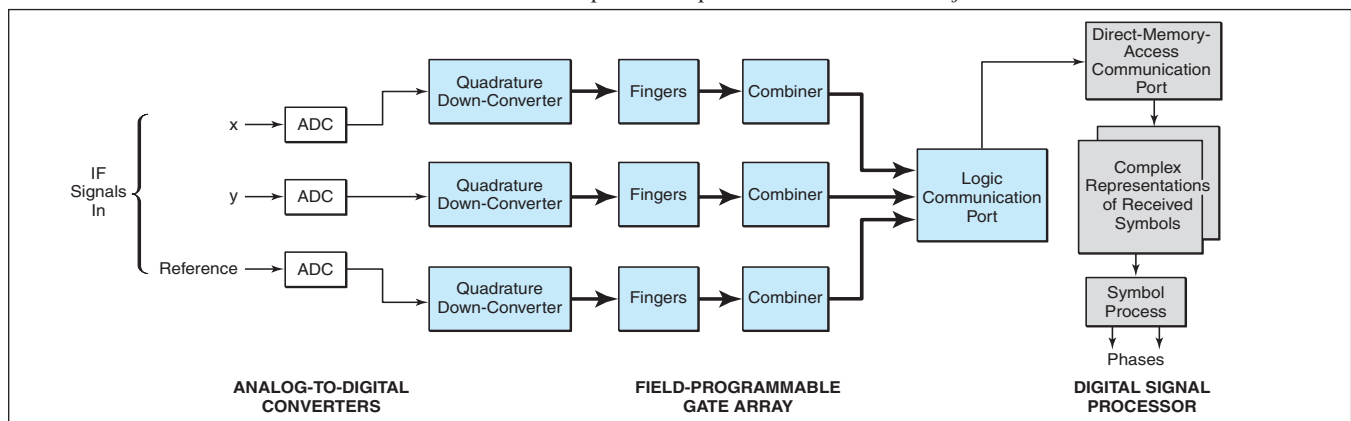


Figure 2. **Signals From the Antenna Elements Would Be Processed** to extract phase differences from modulation. The phase differences would be used to compute the angles θ and ϕ in Figure 1.