LA-UR- 96-3742

CONF-970662--2

Title: A SPACE-BASED RADIO FREQUENCY TRANSIENT EVENT CLASSIFIE~~D~~R

RECEIVED
JAN 17 1997
OSTI

Author(s):
Kurt R. Moore
Philip C. Blain
Michael P. Caffrey
Robert C. Franz
Karen M. Henneke
Rollin G. Jones

MASTER

Submitted to:
International Workshop on Applications of Neural Networks
(and other intelligent systems) to Telecommuncations (IWANNT*97)
Melbourne, Australia
June 9-11, 1997

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Los Alamos
NATIONAL LABORATORY

DISCLAIMER

A Space-based Radio Frequency Transient Event Classifier

K.R. Moore, P.C. Blain, M.P. Caffrey, R.C. Franz, K.M. Henneke, R.G. Jones
Los Alamos National Laboratory

Abstract

The FORTE' (Fast On-Orbit Recording of Transient Events) satellite will record RF transients in space. These transients will be classified onboard the spacecraft with an Event Classifier - specialized hardware that performs signal preprocessing and neural network classification. We describe the Event Classifier, future directions, and implications for telecommunications satellites.

Summary

The FORTE' (Fast On-Orbit Recording of Transient Events) satellite will record 30 to 300 MHz radio frequency (RF) electromagnetic transients in space. These RF transients are produced locally by spacecraft discharges and from below by lightning and man-made sources such as radars. The transients are immersed in a constantly changing background of TV and radio signals. This results in a signal to noise ratio typically well below one. The 800 km circular orbit is above the bulk of the ionosphere. The ionosphere causes dispersion and the variations in the ionosphere cause the dispersion to vary by as much as two orders of magnitude over an orbit.

Even with a front end trigger to select only transient pulses, the data acquisition system memory may fill with raw data in as quickly as a second but can only be dumped to the ground twice a day. Thus, there is a need to reduce the data flow by classifying the transient events selected by the trigger with an Event Classifier (EC) onboard the spacecraft. The EC must be capable of high speed, 100% detection probability, minimal false detection probability operation. The EC must operate reliably in a moderately hostile environment and must have a minimal impact on system resources; i.e., it must be small, light, low power, and require minimal telemetry.

Because radiation hardened analog RF hardware capable of classifying raw RF signals does not currently exist, a digital store and forward system has been constructed. The RF time series is preconditioned, digitized, and stored in memory as event records. The event recording can be triggered either by the RF trigger, by an optical trigger from the onboard optical experiment (built by Sandia National Laboratory), or by the payload controller at predetermined times. These records are then passed to the EC for classification. Typical events contain 50 KBytes so the EC classification into one or two bytes will compress the data flow by a factor of 10^4.

We have built specialized hardware to implement signal processing and neural network algorithms for performing this onboard classification. The EC flight hardware consists of two 6" x 9" circuit boards housed in an aluminum frame and box, draws about 5 Watts of conditioned power, and is designed to withstand 5 krads total dose over the nominal one year mission. The EC consists of a digital signal processor (DSP), a radiation-hardened microprocessor, a programmable gate array, and several types of memory. The microcontroller handles the interface to the spacecraft and the DSP performs the computations. The DSP is susceptible to destructive latchup from radiation effects so three levels of latch detect and reset have been incorporated.

The baseline flight software consists of a multiband trigger, power spectral density estimation algorithms, and self-organizing map and backpropagation neural networks. Algorithm sequences rather than full code modules will be uploaded from the ground. The EC will accept event records from the data acquisition system (through the payload controller), perform the specified algorithm sequence, and produce a classification result formatted for direct downlink in about a second. Most of this time is spent on the data transfer and the power spectral density estimation. The neural networks take very little time.

Neural techniques were chosen because the variable dispersion precludes direct template matching. Analysis of RF events recorded by an existing space experiment indicate that the neural techniques are capable of accurate classification of ionospherically dispersed transients even when the dispersion varies by two orders of magnitude. However, large dispersion results in excessively long input vectors for the networks and efforts are underway to do further feature extraction to reduce the network input vector lengths.

We are concentrating on algorithms that can be implemented in high speed analog hardware in order to eliminate the cumbersome multiband trigger and digital store and forward system in future missions. We are investigating replacing the multiband trigger with a least mean squares time series predictor that can be implemented in high speed, intrinsically radiation hard gallium arsenide analog devices. If high speed gallium arsenide analog compressive receivers could be used for the power spectral density estimation and high speed, radiation hard analog backpropagation network chips being developed by the nuclear physics community could do the classification, the DSP would not be needed. The result would be a more efficient and reliable event classification system.

Telecommunication satellites are susceptible to damage from environmental factors such as deep dielectric charging and surface discharges. The event classifier technology we are developing is capable of sensing the surface discharges and could be useful for mitigating their effects. In addition, the techniques we are using for processing weak signals in noisy environments are relevant to telecommunications.