# Electronics/Computers

## Binary-Signal Recovery

**Application areas include information technology and telemetry.**

*John H. Glenn Research Center, Cleveland, Ohio*

Binary communication through long cables, opto-isolators, isolating transformers, or repeaters can become distorted in characteristic ways. The usual solution is to slow the communication rate, change to a different method, or improve the communication media. It would help if the characteristic distortions could be accommodated at the receiving end to ease the communication problem. The distortions come from loss of the high-frequency content, which adds slopes to the transitions from ones to zeroes and zeroes to ones. This weakens the definition of the ones and zeroes in the time domain. The other major distortion is the reduction of low frequency, which causes the voltage that defines the ones or zeroes to drift out of recognizable range.

This development describes a method for recovering a binary data stream from a signal that has been subjected to a loss of both higher-frequency content and low-frequency content that is essential to define the difference between ones and zeroes. The method makes use of the frequency structure of the waveform created by the data stream, and then enhances the characteristics related to the data to reconstruct the binary switching pattern.

A major issue is simplicity. The approach taken here is to take the first derivative of the signal and then feed it to a hysteresis switch. This is equivalent in practice to using a non-resonant band pass filter feeding a Schmitt trigger. Obviously, the derivative signal needs to be offset to halfway between the thresholds of the hysteresis switch, and amplified so that the derivatives reliably exceed the thresholds.

A transition from a zero to a one is the most substantial, fastest plus movement of voltage, and therefore will create the largest plus first derivative pulse. Since the quiet state of the derivative is sitting between the hysteresis thresholds, the plus pulse exceeds the plus threshold, switching the hysteresis switch plus, which re-establishes the data zero to one transition, except now at the logic levels of the receiving circuit. Similarly, a transition from a one to a zero will be the most substantial and fastest minus movement of voltage and therefore will create the largest minus first derivative pulse. The minus pulse exceeds the minus threshold, switching the hysteresis switch minus, which re-establishes the data one to zero transition.

This innovation has a large increase in tolerance for the degradation of the binary pattern of ones and zeroes, and can reject the introduction of noise in the form of low frequencies that can cause the voltage pattern to drift up or down, and also higher frequencies that are beyond the recognizable content in the binary transitions.

*This work was done by Elmer L. Griebeler of Glenn Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18576-1.*

## Volumetric 3D Display System With Static Screen

**This static glass cube display could enable 3D virtual reality environments that eliminate the need for goggles or helmets.**

*Goddard Space Flight Center, Greenbelt, Maryland*

Current display technology has relied on flat, 2D screens that cannot truly convey the third dimension of visual information: depth. In contrast to conventional visualization that is primarily based on 2D flat screens, the volumetric 3D display possesses a true 3D display volume, and places physically each 3D voxel in displayed 3D images at the true 3D $(x,y,z)$ spatial position. Each voxel, analogous to a pixel in a 2D image, emits light from that position to form a real 3D image in the eyes of the viewers. Such true volumetric 3D display technology provides both physiological (accommodation, convergence, binocular disparity, and motion parallax) and psychological (image size, linear perspective, shading, brightness, etc.) depth cues to human visual systems to help in the perception of 3D objects. In a volumetric 3D display, viewers can watch the displayed 3D images from a completely 360° view without using any special eyewear. The volumetric 3D display techniques may lead to a quantum leap in information display technology and can dramatically change the ways humans interact with computers, which can lead to significant improvements in the efficiency of learning and knowledge management processes.

Within a block of glass, a large amount of tiny dots of voxels are created by using a recently available machining technique called laser subsurface engraving (LSE). The LSE is able to produce tiny physical crack points (as small as 0.05 mm in diameter) at any $(x,y,z)$ location within the cube of transparent material. The crack dots, when illuminated by a light source, scatter the light around and form visible voxels within the 3D volume. The locations of these tiny voxels are strategically determined such that each can be illuminated by a light ray from a high-resolution digital mirror device (DMD) light engine. The distribution of these voxels occupies the full display volume within the static 3D glass screen. This design eliminates any moving screen seen in previous approaches, so there is no image jitter, and has an inherent parallel mechanism for 3D voxel addressing. High spatial resolution is possible with a full color display being easy to implement. The system is low-cost and low-maintenance.

*This work was done by Jason Geng of Xigen LLC for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15606-1*

# MMIC Replacement for Gunn Diode Oscillators

*Goddard Space Flight Center, Greenbelt, Maryland*

An all-solid-state replacement for high-frequency Gunn diode oscillators (GDOs) has been proposed for use in NASA's millimeter- and submillimeter-wave sensing instruments. Highly developed microwave oscillators are used to achieve a low-noise and highly stable reference signal in the 10–40-GHz band. Compact amplifiers and high-power frequency multipliers extend the signal to the 100–500-GHz band with minimal added phase noise and output power sufficient for NASA missions.

This technology can achieve improved output power and frequency agility, while maintaining phase noise and stability comparable to other GDOs. Additional developments of the technology include: a frequency quadrupler to 145 GHz with 18 percent efficiency and 15 percent fixed tuned bandwidth; frequency doublers featuring 124, 240, and 480 GHz; an integrated 874-GHz subharmonic mixer with a mixer noise temperature of 3,000 K DSB (double sideband) and mixer conversion loss of 11.8 dB DSB; a high-efficiency frequency tripler design with peak output power of 23 mW and 14 mW, and efficiency of 16 and 13 percent, respectively; millimeter-wave integrated circuit (MMIC) power amplifiers to the 30–40 GHz band with high DC power efficiency; and an 874-GHz radiometer suitable for airborne observation with state-of-the-art sensitivity at room temperature and less than 5 W of total power consumption.

*This work was done by Thomas W. Crowe and David Porterfield of Virginia Diodes Inc. for Goddard Space Flight Center. Further information is contained in a TSP (see page 1).GSC-15630-1*

# Feature Acquisition With Imbalanced Training Data

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

This work considers cost-sensitive feature acquisition that attempts to classify a candidate datapoint from incomplete information. In this task, an agent acquires features of the datapoint using one or more costly diagnostic tests, and eventually ascribes a classification label. A cost function describes both the penalties for feature acquisition, as well as misclassification errors.

A common solution is a Cost Sensitive Decision Tree (CSDT), a branching sequence of tests with features acquired at interior decision points and class assignment at the leaves. CSDT's can incorporate a wide range of diagnostic tests and can reflect arbitrary cost structures. They are particularly useful for online applications due to their low computational overhead.

In this innovation, CSDT's are applied to cost-sensitive feature acquisition where the goal is to recognize very rare or unique phenomena in real time. Example applications from this domain include four areas. In stream processing, one seeks unique events in a real time data stream that is too large to store. In fault protection, a system must adapt quickly to react to anticipated errors by triggering repair activities or follow-up diagnostics. With real-time sensor networks, one seeks to classify unique, new events as they occur. With observational sciences, a new generation of instrumentation seeks unique events through online analysis of large observational datasets.

This work presents a solution based on transfer learning principles that permits principled CSDT learning while exploiting any prior knowledge of the designer to correct both between-class and within-class imbalance. Training examples are adaptively reweighted based on a decomposition of the data attributes. The result is a new, nonparametric representation that matches the anticipated attribute distribution for the target events.

*This work was done by David R. Thompson, Kiri L. Wagstaff, Walid A. Majid, and Dayton L. Jones of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47562*