TECHNICAL NOTE

EVENT DETECTION DURING ON-LINE PROCESSING*

1. INTRODUCTION

In the study of the electrical discharge characteristics of nerve cells, two of the principal measurements related to activity during various states are the time intervals between impulses and the amplitude of impulses. Several approaches to measuring these quantities have been undertaken in the past. Each is related to the measurement of a short duration event in a very large time scale. The most popular measuring device relates the occurrence of these events by using the event itself as the trigger of a mechanism which counts the elapsed time until the arrival of the next event. Usually such devices retain no amplitude data; nor do they contain any amplitude discriminating properties permitting counting between events of like amplitudes. In the usual batch processing mode of computer operations where jobs are handled one after the other and each job has access to the entire computing facility, the high digitizing rates needed to meet the requirements of high accuracy in time and amplitude measurement can be rather easily met. However, in the realm of time-shared operations with 'real time' processing, extreme difficulty is encountered in maintaining the digitizing rates commensurate with such highly resolved measurements. The following is a description of a system designed within the Brain Research Institute which enables elapsed time resolution, amplitude and amplitude discrimination while providing on-line statistical analysis.

2. BRAIN RESEARCH INSTITUTE COMPUTER SYSTEM

The general configuration of the Brain Research Institute Data Processing Laboratory is illustrated in Fig. 1 (BETYAR, 1967; ROVNER, BROWN and KADO, 1966). The system consists of an SDS 9300 computer with 32,768 words of core storage, three time-multiplexed storage, three time-multiplexed communication channels, two direct access channels and 16 priority interrupts. A System Interface Unit houses the analog-to-digital converter, digital-to-analog converter, and the terminal for the cable distribution system which allows access to the computing facility from any laboratory within the Institute. This facility has been designed specifically to provide on-line time-shared services to the investigators in the Brain Research Institute. Main frame servicing of using activities (e.g., remote consoles, analog-to-digital converters, plotters, etc.) is established through the computer priority interrupt system. Maximum efficient use of the computer (offering service to the largest number of simultaneous users with minimum processing delays) is, therefore, a direct function of efficient use of the interrupt system. Within the system, the analog-to-digital converter occupies the highest priority interrupt and, in addition, places the greatest frequency of requests (directly proportional to the digitizing rate) on the main frame.

Obviously, decreasing the digitizing rate would satisfy the efficiency demanded of time-shared operations, but severely limits the system's ability to respond to requests for processing short duration events by digital means. In order to satisfy the system requirements a combination of digital and analog techniques was developed to meet the specific needs of users requiring event detection.

3. DETECTION OF SHORT DURATION EVENTS

The most common short duration event is the single cell (neuron) firing, or so called 'spike'. The duration of these discharges is short with regard to total time scale (1–5 msec firing time in a total field of 100–500 msec). Due to the shortness of the event, high digitizing rates must be maintained in order to detect its occurrence by digital means.

Figure 2 exemplifies theoretical sampling rate with seven channels of analog input. From this figure it can be seen that those spikes of less than 60 μsec duration may not be detected even if the converter is run at maximum (100 kc) rate. In reality the rate is slowed to a maximum of about 3000 samples/sec per spike channel, which still represents high total conversion rates. A great reduction (10/1) in sampling rate is accomplished by using the original spike data as parallel input to two separate circuits, the Ramp Generator and Peak Follower. The Ramp Generator contains a set of voltage comparators and a sawtooth generator. When the incoming waveform exceeds a previously selected voltage threshold, a ramp is triggered whose linearity is ±5 per cent and whose duration is selectable from 100 μsec to 500 msec. Simultaneously the Peak Follower begins to track the amplitude of the incoming spike. When this spike passes through its maximum value the Peak Follower is clamped and holds this value, retaining it until the next time a spike exceeds the present threshold. The droop of the follower voltage is 10 mV/sec. The outputs from these circuits are fed into two separate multiplexer channels (See Fig. 3).

When digitizing is initiated, the converted values are read into a single large (500–1500 word) buffer in computer memory. When the end of the buffer is reached, new

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DPL data processing system

* Dashed line indicates planned system expansion

**FIG. 1**

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30 analog inputs
16 analog inputs
24 relay driver output
24 sense line input

Number 1

Scope displays
Console system output memory scope

Number 2

Number 3

Graph plotter 1
Graph plotter 2
Tele-type writer
Line printer
Card reader 200 c/min
Paper tape reader
Paper tape punch
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**FIG. 2**

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Channel active (sampling) 10μsec
Channel inactive (waiting) 60μsec
Imaginary data
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