RETINAL-TYPE NEURISTOR SECTIONS

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Abstract

The A, B^+, B^-, G, H, and R neural-type circuit modules are introduced. These are motivated by physiological cells associated with the retina and are of such a nature that the modules can be realized by CMOS transistor circuits. Desired properties of the modules are listed and some basic interconnections given.

I. INTRODUCTION

In the early 1960's H. Crane introduced the neuristor [1] as a basic component for new types of systems. However, due to a lack of useful realizations the ideas lay dormant until recently when breakthroughs in circuits realizable in integrated circuit (IC) and very large scale IC (VLSI) took place [2] [3]. Consequently these new realizations are being looked at in terms of various applications [4]. One such application would appear to be in the design of systems which have pulse processing behavior similar to the retina [5] [6]. Consequently, here we introduce classes of neural-type modules which appear to be important to the attainment of this goal.

II. THE NEURAL-TYPE MODULES

Based upon the properties of biological cells associated with the retina [7] we introduce five types of circuit modules, as follows:

a) A-Modules: The A-Module circuits generate a single "all-or-none" response to polarized (multiple) inputs with levels above threshold; they respond with a single pulse to inputs crossing, and remaining above, threshold.
The A-modules behave like the biological amacrine cell for which they are named.
b) B-Modules: The B-Module circuits generate slow, graded (single output) responses to (multiple) inputs coming from R-modules and single H-modules (defined below). These inputs are summed to give the B-module output. This summation is nonlinear, but monotonic, and shows quick saturation when sufficient inputs are excited. There are two types for negative (B^-module) and positive (B^+-module) going pulse inputs from H-modules. This leads to two correspondingly different polarity types of the output signal.
B-modules behave like bipolar cells for which there are those that are stimulated to give excitatory outputs and those that are stimulated to give inhibitory outputs.
c) G-module: The G-module circuits get their (multiple) input signals from A- and B-modules. On a single output lead these circuits generate "all-or-none" responses to positive input pulses and have repetitive spike train outputs with a frequency dependent on the level of the input.
The G-modules behave like ganglion cells.
d) H-module: The H-module circuits take their (multiple) inputs through R-modules (defined below) and give slow, graded responses, there being simultaneous positive and negative outputs. As with B-modules, the inputs are summed nonlinearly, monotonically, and with quick saturation when there is sufficient input.
H-modules are analogous to biological cells that are structurally positioned such as to allow for horizontal spread of signals, justifying their name.
e) R-modules: The R-module circuit converts a single external pulse signal (of varying heights) to two (classes of) positive going output voltages on a logarithmic scale. These outputs of the R-module are connected to H-modules and B-modules, respectively.
R-modules behave like receptor cells of the retina.

III. FUNCTIONAL INTERCONNECTIONS

Given the basic modules these may be interconnected to yield various pulse processing capabilities. Figure 1 shows three of the possibilities with the names derived from the functions perceived for the analogous interconnections of biological cells.

IV. DISCUSSION

Here we have outlined the properties to be sought in five classes of basic neural-type circuit modules, these properties being those important to five analogous biological types of cells. With these properties on hand CMOS circuits are under design to realize the desired properties and mathematical characterizations are being developed to describe them.

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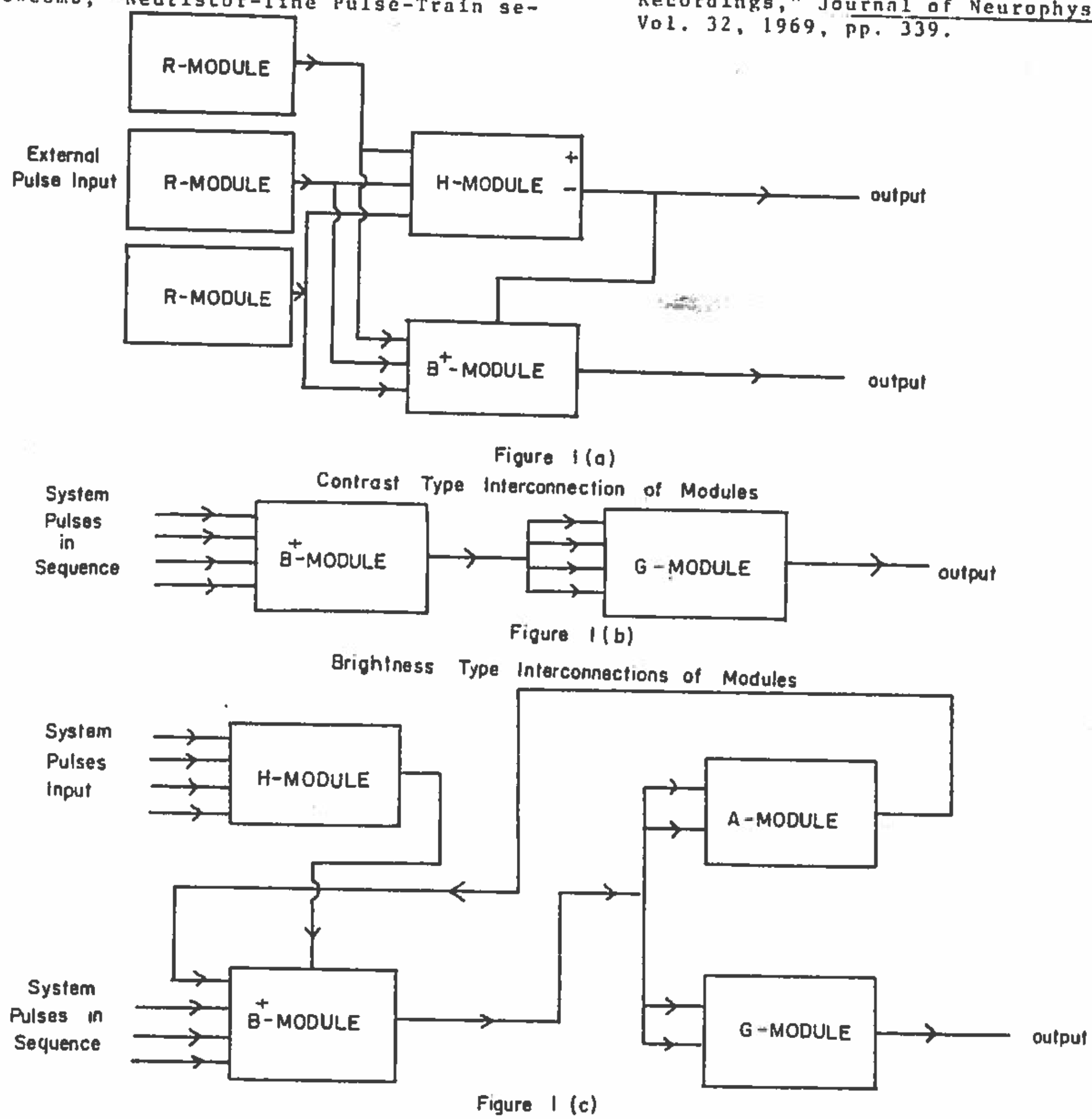
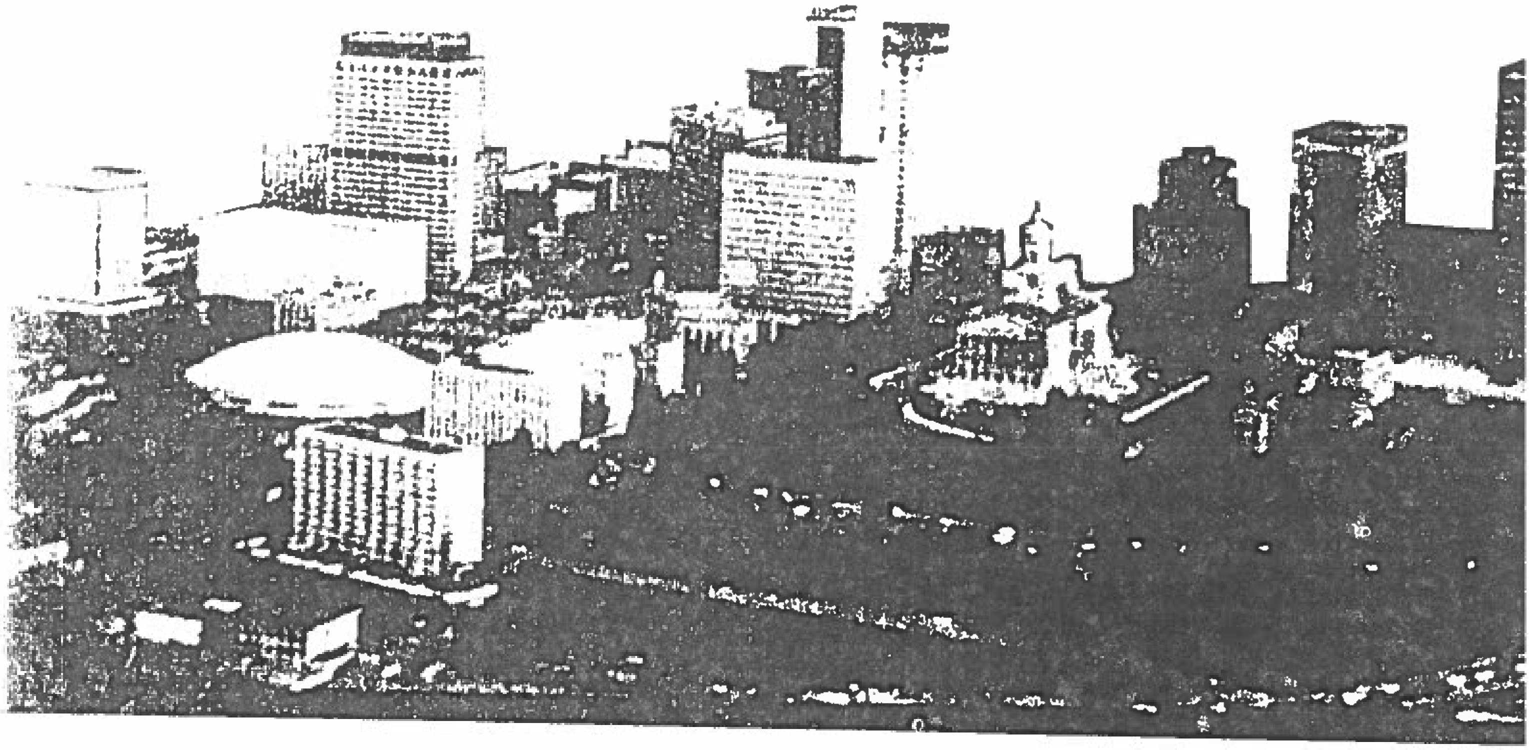


Figure 1(a)
Contrast Type Interconnection of Modules

Figure 1(b)
Brightness Type Interconnections of Modules

Figure 1 (c)
Movement Detection and Coding Type Interconnections of Modules

FIGURE 1
TYPICAL INTERCONNECTIONS



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