# PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

## Adaptive Element

We, STANDARD TELEPHONES AND CABLES LIMITED, a British Company, of STC House, 190 Strand, London, W.C.2, England do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to adaptive information storage devices, that is to say, to finite-state memory devices whose stored values progressively approximate to or estimate statistical measures of their inputs, and has particular application in connection with elements such as that described in our British Patent Specification Serial No. 1,069,159.

In what follows, the expression "adaptive element" is taken to mean an information storage device which includes at least one element whose state or condition determines a linear range of storage levels, the state or condition of the said element or elements being arranged to change in such a way in response to signals input to the device that the magnitude of the change in the stored level made by the device in response to an individual input signal has a value determined directly or statistically by the values of two or more parameters which include the value of the input signal and also the level stored in the device immediately prior to receiving the said signal, and the term "information processing arrangement" is taken to include for example the backing store of a digital computer, the computer itself, the central processor and decision elements therein, as also the methods of or devices for implementing numerical computation, simulation, speech or pattern recognition, process control and the storage of intermediate results in a logical or arithmetical operation.

For constant environmental conditions, the value of the element is a function to which the sequence of successive counter values converges.

The term instantaneous store value is used to mean the current value of the randomly modified store at the instant of sampling.

Counters having incrementing and decrementing facilities may either possess separate increment and decrement lines or else may distinguish by the form of the signal (e.g. +1 or −1) whether incrementing or decrementing is intended.

According to the invention there is provided an information processing arrangement which includes an adaptive element containing a store the value of which is continually randomly modified and a counter the value of which is repeatedly compared with the instantaneous value of the randomly modified store, being appropriately modified according to the results of the comparison, the adaptive element having associated therewith a limit store with adjustable setting the maximum setting of which does not exceed the greatest value expressible by the counter, the value of the randomly modified store being maintained below the value of the limit store.

The arrangement described thus provides a way of reading the value of an adaptive element probabilistically and of modifying the value of the element probabilistically and of making the response rate of the element (equivalently the length of the integrating sequence which is necessary) controllable.

The above mentioned and other features of the invention will become more apparent and the invention itself will be best understood by reference to the following description taken in conjunction with the single figure of the accompanying drawing which is a block

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diagram of an embodiment of the invention.

In the embodiment illustrated, 1 is a counter having increment and decrement lines and holding a value x of a first quantity. 2 is a store which holds the value y of a second quantity. The value x is limited to lie in that range which can be represented as a level or combination of levels of the multistable device or devices in the counter. The value y is constrained so as to lie in the range between zero and Y MAX, where Y MAX is determined by an external control and where Y MAX is in any case not greater than the maximum value which the adaptive element can assume.

The values x and y are compared by comparator units 3 and 4, 3 outputting a signal when x is strictly greater than y and 4 outputing a signal when x is less than or equal to y. The output of 3, which is present if x is greater than y, is gated at AND gate 5 with a "read" signal and the value of x (stored in 1 as a combination of states of multistable devices, for example bistables) is read out as a sequence of pulses, giving the value of the element for condition A.

The output of 3 is separately gated also at the AND gate 7 with the "write" command signal for condition B (i.e. not-A) and applied to the decrement line of the counter 1.

Thus if on the application of a read pulse the contents of the counter 1 exceed the contents of the store 2, the sequence representing the value of the element for A is read out and the counter is decremented by the application of a "write B" pulse, where B is the condition not obtaining for the sequence which is read out.

Similarly, if x is less than or equal to y, the sequence representing the contents of the adaptive element is obtained by gating at AND gate 6 the "read" signal with the output of comparator unit 4.

The output of 4 is separately gated also at the AND gate 8 with the command signal for condition A and applied to the increment line of the counter 1. Thus if the contents of the counter are less than the contents of the store, the sequence corresponding to condition B is output and the value of the counter is incremented by a "write A" pulse.

The duration of the "read" signal is sufficient to allow the full word length of the adaptive element to be read out.

An obvious alternative arrangement is the embodiment in which the comparator unit 3 is activated when the counter value is greater than or equal to the store value, while the comparator unit 4 is only activated by a counter value which is strictly less than the store value.

The signals "write A" and "write B" are obtained e.g. when a sensor at an interface registers a variation in input from the environment or when a decision followed by branching sends an ON or an OFF signal to the adaptive element.

The store value is continually being randomly modified by signals from a random modifier 9. Thus comparisons are continually being made by the comparators 3 and 4 and signals are continually being sent to gates 7 and 8, tending to decrement or increment as appropriate the quantity stored in 1. Thus modification of the counter value is continual, proceeding more rapidly where there is a wide divergence between x and y, and less rapidly in the less sensitive regions where x and y are nearly equal. Since the contents y of store 2 are constrained not to exceed Y MAX, 2 is re-cycled to zero when a positive random increment would cause the constraint to be violated.

The boxes 1 to 9, together with provision for interconnection for operation in such a way that the store value is continuously randomly modified and on the application of an appropriate signal the counter value is read out wherein the counter value is compared with the instantaneous store value and an indication provided at to which of the values is the greater, the counter value being decremented or incremented in the presence of an appropriate signal according to the counter value exceeds or does not exceed the store value, are thus a form of adaptive element.

The value of y, though randomly varying, is maintained by an external control below a maximum value Y MAX.

In the embodiment illustrated, this external control is provided by a store 10 which is set at value Y MAX and which limits the value of the randomly modified store 2. Y MAX does not exceed the greatest value expressible by the adaptive element, otherwise comparator 4 would be activated more frequently than is necessary to ensure convergence in the performance of the adaptive element, which would not be the most efficient mode of operation. Limiting Y MAX also results in preventing overcounting by the counter.

The rate of variation of the value of the element is thus externally controllable by manually altering the contents of store 10.

The pulses "write A" and "write B" in the embodiment illustrated are complementary i.e. if B is 0, A is 1 and vice versa. However if the logic scheme employed is not simply binary, A need not be precisely not-B, and conversely (for example, in a ternary logic scheme, three conditions ON, OFF and OPEN exist; there are also threshold logic schemes in which peak decision points are separated by areas of no-man's land).

The embodiment of the invention which is hereinbefore described is conveniently realised using electronic components, but may also be realised using mechanical elements or

devices using magnetic, pneumatic, fluid or other forms of logic.

WHAT WE CLAIM IS:—

1. An information processing arrangement which includes an adaptive element containing a store the value of which is continually randomly modified and a counter the value of which is repeatedly compared with the instantaneous value of the randomly modified store, being then appropriately modified according to the results of the comparison, the adaptive element having associated therewith a limit store with adjustable setting the maximum setting of which does not exceed the greatest value expressible by the counter, the value of the randomly modified store being maintained below the value of the limit store.

2. An arrangement as claimed in claim 1 wherein the setting of the limit store is manually adjustable.

3. An arrangement as claimed in either one of the preceding claims wherein signals are represented according to a binary logic scheme.

4. An arrangement substantially as hereinbefore described with reference to the single figure of the accompanying drawing.

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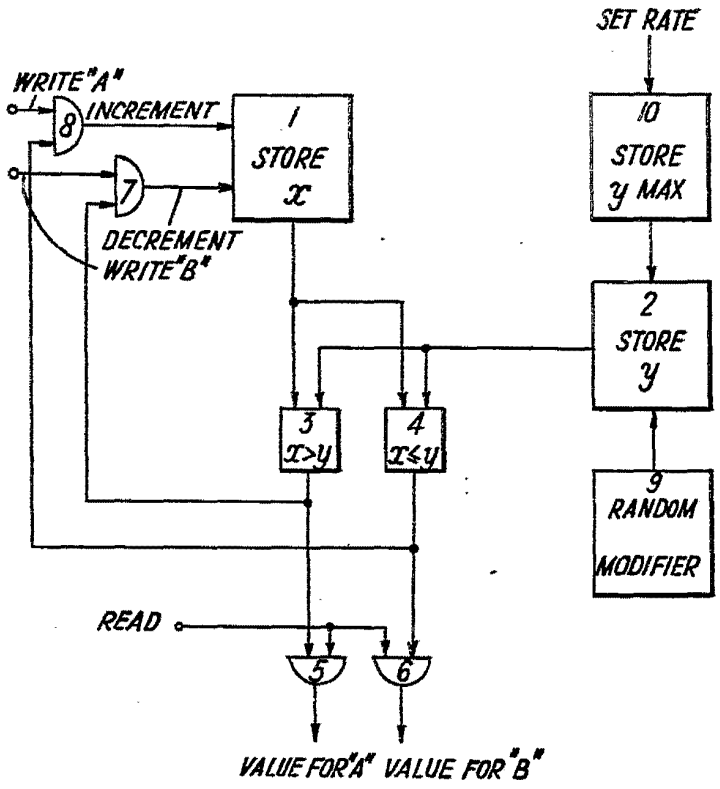
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