MOS Implementation for Short Term Changes in Neural-Type Cells*

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Abstract:

An MOS addition (FACIL module) to the neural-type cell (NTC) is proposed which captures the short term changes in synaptic efficacy of biological neurons. This addition is an adaptation of the FACIL module of Hartline's SYNETSIM and adds flexibility to microelectronic neural network implementations based upon the NTC.

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I. Introduction

In the past we have designed various modules of neural-type microsystems which capture neurobiological signal processing in microelectronic hardware [1]. Attention has been focused on the neural-type cell (NTC) which is the key encoder of neural-type signals. At this point we are able to design NTCs so that they mimic trigger-zone properties of neurons. Exposure to Dr. D. K. Hartline's program SYNETSIM [2] has introduced us to a wider range of behavioral phenomena crucial to realistic implementation of neural-type microsystem. One such phenomenon is the ability of neurons to respond very dynamically to repeated presynaptic activity. In order to predict the output resulting from a given stimulus to a nerve terminal it is necessary to determine how synaptic efficacy changes as a function of the stimulation pattern. For this purpose the FACIL module is introduced here based upon Hartline's facilitation pools.

II. The FACIL Module

In the FACIL module there are four kinetically separable components of increased transmitter release: F1, F2, A, P where F1 and F2 are the first and second components of facilitation, A is augmentation and P is potentiation. The components are identified on the basis of their time constants of decay and their fractional contribution to the output. The input to the FACIL module is the output of the NTC, yNTC, as shown in Fig. 1, and the output of FACIL is expressed by

$$yFACIL = (F1 + F2 + 1)^3*(A + 1)*(P + 1) \qquad (1)$$

where F1, F2, A, and P satisfy the following differential equations.

$$dF1/dt = f1*yNTC - K1*F1 \qquad (2a)$$

$$dF2/dt = f2*yNTC - K2*F2 \qquad (2b)$$

$$dA/dt = a*yNTC - K3*A \qquad (2c)$$

$$dP/dt = p*yNTC - K4*P \qquad (2d)$$

Here f1, f2, a, p, are constants representing the fractional contributions of each component and the Ki's, i=1,...,4, represent their respective decay constants.

III. Simulations

In the final paper PSPICE simulations and circuit designs will be given.

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                 ***********          ***********
input            *         *  yNTC    *         *  yFACIL
---->------*    NTC     *---->-----*   FACIL   *--->---
                 *         *          *         *
                 ***********          ***********
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Figure 1
Connection of FACIL to NTC

References:

1. N. El-Leithy and R. W. Newcomb, "Overview of Neural-Type Electroncs," 28th Midwest Symposium on Circuits and Systems, Louisville, KY, August 1985, pp. 199 - 202.

2. D. K. Hartline, "Simulation of Restricted Neural Networks with Reprogrammable Neurons," IEEE Transactions on Circuits and Systems, Vol. 36, No. 5, May 1989, pp. 653 -660.

Dear Professor Elmasry - I hope the above abstract and summary arrive to you ok. Best regards, Bob Newcomb 05/01/91 17:35

Prof. Newco[illegible]
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