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FRACTAL DIMENSION AND TEMPORAL EVOLUTION OF NEURONS

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1. Introduction. Neurons are cells with a special morphology; their functionality depends on the number of endings (called *neurites*). This morphology is the result of many factors, e.g. nutrient, enviroment or genetic. The initially round body generates small prolongations which, depending on the enviroment, might grow to become the axon and the dendrites. It has been shown that cells in the nervous system such as neurons [1] and glial cells [2] have a fractal dimension [3,4]. The more complex the celular morphology the larger the fractal dimension. In this way, studying the evolution of the fractal dimension of a neuron can provide information about the synaptic connectivity. The fractal dimension of laboratory grown neurons has been studied as a function of time in order to characterize the complexity of the neuron morphology by its fractal dimension, $D_f(t)$.

2. Methodology. Hippocampal neurons were taken from rat brains (after 18 days of gestation) and were subsequently grown in the laboratory. Individual cells were arranged on a dish with special adhesive substrate having a density of 15000 neurons/cm^2, and were set in a suitable atmosphere. Various neurons profiles were measured using a microscope with a magnification of 400×, at specific time intervals for 30 hours. The images were digitalized with a resolution of 2283x2283 pixels.

3. Results. The fractal dimension is measured using the box-counting method for three neurons at each time interval. The same value $D_f(t)$ was obtained for all neurons in the same interval time. In Fig.1(a) the fractal dimension calculation for three neurons after 30 hours is shown. However, calculating D_f for each neuron at different time intervals shows that this value increases with time, as is shown in Fig. 1(b). The temporal evolution of $D_f(t)$ follows a decreasing exponential type growth :

$$D_f(t) = A + Bexp{-t/\tau}, \tag{1}$$

where τ is the time constant independent of the chosen neuron, as shown in Fig. 2. The inset shows an example of a digitalized neuron. This fractal dimension behaviour has been previously reported in [2] for cultured glial cells and [5] for spinal cord cells. It should be noted that the fractal dimension found in [5] for 3/4-type spinal cord cells and the 3/4-type hippocampal neurons has the same numerical value.

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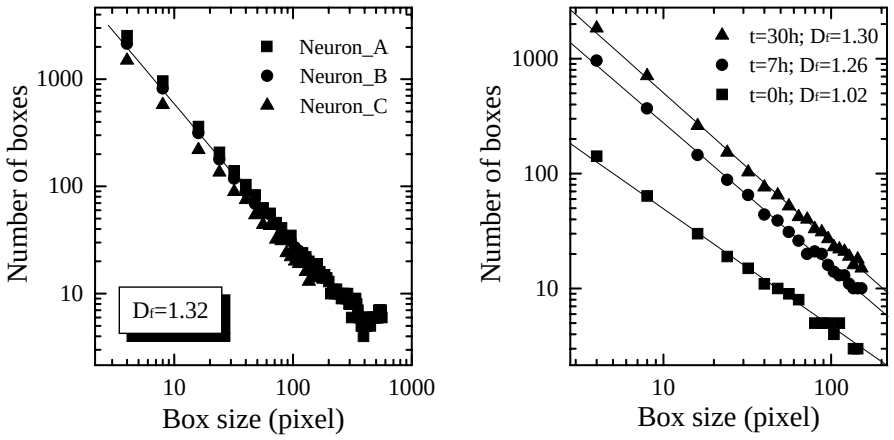

FIG.1. *Fractal dimension: (a) Same time (t=30h) and different neurons. (b) Same neuron and different times (t=0h, t=7h, t=30h).*

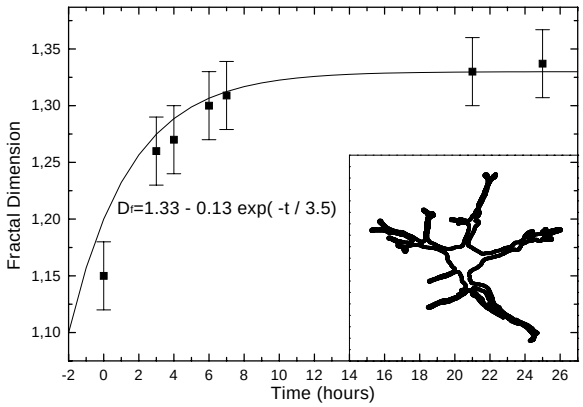

FIG.2. *Temporal evolution of the fractal dimension. Inset, digitalizated image of a neuron at t=29h.*

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