Concept of artificial neural network (ANN) and its application in cerebral aneurism with multi walls carbon nanotubes (MWCNT)

RODICA-MARIANA ION
ICECHIM, Analytical Department, Bucharest, ROMANIA;
Faculty of Materials Engineering, Mechatronics and Robotics, Valahia University,
Targoviste, ROMANIA;
E-mail: rodica_ion2000@yahoo.co.uk

DANIEL MUNTEANU
Faculty of Materials Engineering, Mechatronics and Robotics, Valahia University,
Targoviste, ROMANIA;
E-mail: daniellmunteanu@yahoo.com

GEORGE - COSTEL COCINA
Faculty of Biology – BCUM-NFM Research Center,
University of Bucharest, ROMANIA
E-mail: gccocina@yahoo.com

Abstract: - This paper describes the distinct properties of carbon nanotubes, and their use for biomedical applications. An innovative architecture for medical use of nanorobots are proposed as an advanced and precise tool for brain aneurism instrumentation as nanorobots.

The nanotubes include their nanometer diameter (~0.4 nm to >3 nm (single walls carbon nanotubes - SWCNTs) and ~1.4 nm to >100 nm (multi walls carbon nanotubes - MWNTs), length of several micrometers (up to centimeters), large aspect ratio (10–1000). The columnar structure of multi walls carbon nanotubes (MWCNT) is responsible for the special properties. In this paper, the controlled activity of MWCNT was studied at room temperature on dissociated cortical cultures from mice which supported a cerebral aneurism. Neurons and glial cells incubated for several days with this nanotube yielded to some connections between the islands are clearly apparent and interconnected networks are formed following the exact pattern of the MWCNT (nanotube) templates. The bridging consists either of an axon or bundles of axons and dendrites. Three days after incubation with MWCNT, show that cells first aggregate at the MWCNT islands. As they complete this step axons and dendrites begin to form and to build connections.

Key-Words: - Artificial neural network (ANN); SWCNT, Artificial intelligence (AI), cerebral aneurism, neuron, nanorobots

1 Introduction

Artificial neural networks (ANNs) are formed from hundreds of single units, artificial neurons or processing elements (PE), connected with coefficients (weights), which constitute the neural structure and are organised in layers. The power of neural computations comes from connecting neurons in a network. The behavior of a neural network is determined by the transfer functions of its neurons, by the learning rule, and by the architecture itself. ANN represents a promising modeling technique, especially for data sets having non-linear relationships which are frequently encountered in pharmaceutical processes. The potential applications of ANN methodology in the pharmaceutical sciences range from interpretation of analytical data, drug and dosage form design through biopharmacy to clinical pharmacy [1].

A neuron is the basic element of the brain. A diagram of a neuron is detailed in Figure 1.

Figure 1 Structure of a biological neuron.
The structure of the brain is an interconnection of a very large (tens of billions) number of neurons. The transmission of signals in the brain is chemical in nature. Each neuron receives an input signal from other neighbouring neurons. The connection path between two neurons is called an oxon and the incoming ports dendrites. Impulses pass along the axon to the synapse, the junction between one neuron and the next and signals are passed from one to the next in an all-or-none fashion. Neurons are organised in a fully connected network and act like messenger in receiving and sending impulses. The result is an intelligent brain capable of learning, prediction and recognition [2].

The connections between axons and dendrites are called synapse (Figure 2). In order to understand the biological model, the axon is an electrical cable and the dendrites is a socket. To carry information a link is required. The synapse, the link or plug, changes the effectiveness of the incoming spike. During the learning phase the efficiency of the synapse is modified. The sum of the incoming signals, the total input, is used by the receiving neuron to generate an output. 

This output of one neuron is the input for many other neurons except those neurons in the output layer.

Figure 2. Synapse

The artificial neuron is the building component of the ANN designed to simulate the function of the biological neuron [3]. The arriving signals, called inputs, multiplied by the connection weights (adjusted) are first summed (combined) and then passed through a transfer function to produce the output for that neuron (Fig.3).

Figure 3. The signals way

The artificial neuron is a simple model of the biological neuron which has the form as displayed in Figure 3.

Nanorobots are nanodevices that will be used for the purpose of maintaining and protecting the human body against pathogens. They will have a diameter of about 0.5 to 3 microns and will be constructed out of parts with dimensions in the range of 1 to 100 nanometers. The main element used will be carbon in the form of diamond / fullerene nanocomposites because of the strength and chemical inertness of these forms. Many other light elements such as oxygen and nitrogen can be used for special purposes [4].

Some possible applications using nanorobots are to cure skin diseases, by using a cream containing nanorobots for removing the right amount of dead skin, remove excess oils, add missing oils, apply the right amounts of natural moisturising compounds to create smart nanomachines which could identify and destroy pathogenic bacteria while allowing the harmless flora of the mouth to flourish in a healthy ecosystem, for new medical nanodevices for finding and disabling unwanted bacteria and viruses and for devices working for nibbling away at arteriosclerotic deposits, widening the affected blood vessels, that could restore artery walls and artery linings to health [5].

However, it is clear that nanotechnology is progressing toward the construction of structures, tools, sensors, actuators, and systems smaller than 100 nm that will extend our ability to explore the nanoworld from perception, cognition, and manipulation perspectives. In the present, discovery of new structures for performant nanorobots, are one of the most interesting area.

For nanorobotics, some of the most important characteristics of nanotubes include their nanometer diameter (~0.4 nm to >3 nm (SWCNTs) and ~1.4 nm to >100 nm (MWNTs), length of several micrometers (up to centimeters), large aspect ratio (10–1000), terapascal scale Young’s modulus, excellent elasticity, ultrasmall interlayer friction, excellent field-emission properties, current carrying capacity (~1 TA/cm3), high heat transmission (~3 kW/mK). NTs can serve in nanorobotic systems as structural elements, tools, sensors, and actuators. The discovery of nanotubes (NTs) has the potential of revolutionizing the biomedical research as they can show superior performance because of their impressive structural, mechanical and electronic properties [6,7]. By assembling as-grown NTs, more complex structures can be built. Nanotube intermolecular and intramolecular junctions are
basic elements for such structures. Interlayer motion between individual carbon shells, which are cylindrically nested and suspended by van der Waals forces within a MWNT, provide exceptional performance as linear and rotary nanobearings. A conclusive example is

With its hollow core, MWCNT is possible to generate new glial brain connections, proper for biomedical applications. Different drug molecules could be inserted into NTs via an extremely rapid dynamic interaction process. The application of NTs to deliver drugs and act to the central nervous system beyond the blood–brain barrier is discussed. If this finding is found successful, NTs can be used for treating eye diseases and other diseases such as Alzheimer’s and Parkinson’s. Endovascular treatment of brain aneurysms, arteriovenous malformations, and arteriovenous fistulas are biomedical problems expected to benefit from current research and developments in the field medical nanorobotics [6]. The application of medical nanorobots for brain aneurysm is presented in this work.

2. EXPERIMENTAL PART
2.1. Materials and methods

MWCNT-10  diameter <10nm, length 5-15 mm, 95% purity, surface area 40-300 m$^2$/g amorphous carbon, amorphous carbon <3%.
MWCNT-40-60  diameter 40-60 nm, length 5-15 mm, 95% purity, surface area 40-300 m$^2$/g amorphous carbon, amorphous carbon <3%.

Figure 4. The structure of SWCNT and MWCNT

2.2. Apparatus

A Hitachi S-2700 electron microscope operating at 10 kV, was used to obtain TEM images. Pictures were taken by a camera (SC35, Olympus, Japan) mounted on an optical microscope (IX-70, Olympus), using the x40 and x100 magnifications, and Nikon camera mounted on an Nikon fluorescence microscope, using the x10 and x40 magnifications. SEM images have ben obtained with a scanning electron microscope Nikon T600 laser scanning microscope. The images were collected with an immersion objective and displayed on a charge-coupled device camera.

2.3. Cell cultures

Dissociated cortical cultures from mice, were prepared and maintained as follows: the entire cortices from one-day-old Charles River rats were finely chopped. The cortical tissue was digested with 0.065% trypsin in phosphate buffered saline, for 15 min, followed by mechanical dissociation by trituration. Cells were resuspended in a modified essential medium with Eagle’s salts containing 5% horse serum, 1 mg/ml gentamycin, and 0.02mM glucose. The cultures were maintained in growth conditions at 37.1°C with 5% CO2 and 95% humidity. Half of the growth medium was replaced twice a week.

3. RESULTS AND DISCUSSION

It is well known that glial cells account for 90% of cells in the adult human brain. Also, it is now known that neuron-to-neuron communication is controlled by the glial cells. Glial cells tell neurons to start communicating with one another. Before neurons can send and receive messages they must establish connections called synapses (points of near-contact where neurons swap chemical signals). Unfortunately, neurons cannot build very efficient synapses on their own. It was speculated that the glial cell either turned up the volume on the neuron transmitting the signal or it increased the sensitivity of the neuron receiving the signal. No one expected to find the glial cells controlling the number of synapses. In this paper it is established that new glial cells could be generated after a cerebral aneurism only by treating the animal with MWCNT.

From the analysis of the images it is noted that the MWCNT is a complex process occurring by fractal aggregation [7]. Neurons and glial cells were formed after cells incubation for several days with MWCNT. After four days neurons have aggregated and accumulated on the MWCNT coated regions. Moreover, connections between the islands are clearly apparent and interconnected networks are formed following the exact pattern of the MWCNT templates. The bridging consists either of an axon or bundles of axons and dendrites. In some cases the bridge is covered with clusters of cells. These bridges form very efficiently over quartz surfaces which are apparently very poor surfaces for cell attachment. Fig. 5 shows the evolution of a network after three days (a) and
five days (b), respectively, after incubation. The data show that cells first aggregate at the MWCNT islands. As they complete this step axons and dendrites begin to form and to build connections.

**FIGURE 5.** The microscopy images fo neuronal cells after 3 days (a) and five days (b) after incubation with MWCNT nanotubes 10 microg/ml.

### 4. CONCLUSIONS

Neurons and glial cells were incubated for several days in order to investigate the effectiveness of the method. Connections between the islands are clearly apparent and interconnected networks are formed following the exact pattern of the MWCNT templates. The bridging consists either of an axon or bundles of axons and dendrites. A networkover after three and five days after incubation, has been observed. The data show that cells first aggregate at the MWCNT islands. As they complete this step axons and dendrites begin to form and to build connections.

### References: