Scientific Report

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Period of the fellowship	15/08/2011 to 14/08/2012

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

My research activity during the fellowship was mainly focused on nanocommunication network design. The nanocommunication networking provides engineering solutions at the scale of a few nano meter using nanomachines, to sense, process, and communicate efficiently. In this research, firstly the most important literatures and contributions in nano networking have been reviewed, and the major demands and challenges were considered. Moreover, the feasibility of design and application of classical communication for nano networking was elaborated. In a nano scale network, the communication would be either molecular, by transmission of signals through molecular diffusion, or electromagnetic using electromagnetic transceivers i.e. carbon nanotube antennas. An application area for nano networking is the human biological system which was investigated during the ERCIM period. A biological network consists of millions of neural cells and each has three main elements including the dendrites, soma, and an axon in order to receive, process, and transmit the signals from presynaptic neurons to the postsynaptic connections.

In this research, the spiking neural network was studied, to propose new communication model for biological network. Various modelling algorithms have been considered, including classical techniques such as leaky integrate and fire, Hodgkin-Huxley, and FitzHugh-Nagumo, or the recently-proposed techniques such as Moris-Lecar, Hindmarsh, and Izhikevich The idea of employing nanotechnology for fault diagnosis was applied on the spiking neural architectures using the Izhikevich model. The neural cell repair relates to detect the faults, isolate the damaged cells, distribute the task to the available neighbouring neurons, and to replace them by artificial nano machines. Once some neural cells become faulty, the fully-connected biological network would be a randomly connected net. To avoid the disconnection in the network, the neural cells are expected to transmit the signals through remaining neural cells. To reorganize the neural cell connections after fault diagnosis, a depth-first search algorithm was implemented to reestablish a small-world biological network.

At the final part of the ERCIM visiting period, noise characterization was considered in a neural nanocommunication system. Therefore, the behaviour of the neuron was statistically evaluated and a more generalized form was identified for noise characterization. A new stochastic network including various disturbance sources was proposed for a noisy neuron in a nanocommunication network. The new idea was to apply different noise sources at the same time, on various parts of the neuron. Later, a generalized model was presented and the numerical results for the derived stochastic model were presented.
In addition to research on nanocommunication, I had the opportunity to extend my research on communication network design and analysis. I had presentations in some conferences, workshops, and visiting ERCIM institutes. I was a TPC member of international conferences i.e. IEEE PIMRC, and reviewer of many scientific journals i.e. Applied Soft Computing and ITS.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

1. Amir Jabbari and Ilangko Balasingham, "On the Modelling of a Communication Network using A Spiking Architecture." In the Proceeding of the IEEE MoNaCom, ICC, Canada, Jun. 2012 (Published).

Abstract: The human neural system is comprised of millions of neural cells which are fully networked through synaptic connections. Each neuron receives the input through dendrites from neighboring nodes, in order to fire an action potential through its axon into the next neurons. In this paper, a biological communication network is modeled and a scenario is implemented to detect the damaged neural cells. For this purpose, the membrane potential of the biological network nodes is monitored and evaluated using spiking neural network algorithm. A spiking Izhikevich neural modeling technique is implemented at nanoscale to model the biological network. A swarm of nanobots is taken into consideration to diagnose the malfunction of the biological communication network by measuring the membrane potential of each firing neuron and the neighboring nodes.

After fault occurrence, some nodes will no longer be available to process and communicate in the biological communication network. Therefore, the fully-connected biological network as a small-world network would be a randomly-connected communication network. The idea of this research is to diagnose the defected nano-cells and autonomously cluster to regenerate a small-world network using the available neighboring neural cells. To reestablish the small-world biological communication network, a graph theory scheme is applied considering the membrane potentials and coordination of the neural cells. The depth-first search algorithm is implemented for clustering and the simulation results are illustrated and discussed.

2. Amir Jabbari and Ilangko Balasingham, "Modelling Nano communication Networks Using Neurocomputing". In the Proceeding of the 4th IEEE International Symposium on Applied Sciences in Biomedical and Communication Technologies, Spain, Oct. 2011 (Published).

Abstract: In this paper, a practical neurocomputing algorithm is introduced and elaborated in order to design and implement a nano-communication network for various applications such as medical and industrial signal processing. Firstly, the idea of artificial neural network for data processing is explained and feasibility of modeling a nano-scale network by an optimized neurocomputing algorithm is discussed using binary neuro-modeling. Moreover, it is stressed how nano-scaling increases the complexity of the communication network considering the existing constraints on computation resources, and accuracy of the proposed networking algorithm, either for communication or computation. Furthermore, the developed nano-scale networking technique is more optimized in order to assist the so-called neural nano-machines, to conduct the simple nano-nodes working more effectively and collaboratively. To experiment the performance of the presented bio-inspired nano-network, a test scenario is implemented to compare the accuracy of data processing techniques, showing how a large-scale network is replaced by an efficient nano-scale networking algorithm. Finally, the obtained results are illustrated and more elaborated to provide a complete procedure for future developments of the bio-inspired networking in nano-scale.

3. Amir Jabbari and Ilangko Balasingham, "Noise Characterization in a Stochastic Neural Communication Network", IEEE Journal on Selected Areas in Communications - Special Issue on Emerging Technologies in Communications - Area 8: Nanoscale and Molecular Networking, 2013 (Submitted).

Abstract: A biological neural system is comprised of millions of interconnected neurons which are networked through synaptic connections in human body. The signals are encoded, propagated through synaptic channels, and decoded at every neuron in order to transmit a signal. The desired performance of the network would be influenced by either internal or external disturbances i.e. the spiking irregularities, history of firing in the neural cell, and the randomness in release of the neurotransmitters depending on the operating frequency. In this paper, firstly a noise-free biological neural network is stochastically modeled. The internal and external disturbance sources are characterized in terms of in-body communications and a comprehensive stochastic model is developed to verify the effects of the various noise sources. The proposed model is comprised of encoding noise and synaptic/ionic disturbances. An effective probabilistic algorithm is given to model the firing rate and timings of the neuron in presence of disturbances in the proposed stochastic network. The proposed model is numerically studied and simulated, when various noise sources are applied simultaneously on the neural communication network.

* In addition, the extended version of the paper "On the Modelling of a Communication Network using A Spiking Architecture" was officially invited to submit in Nano Communication Networks Journal, Elsevier.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

1. The Second International MELODY Project Workshop
   Oslo University Hospital, Rikshospitalet - Oslo (Norway)
   October 17-18, 2011

2. ISABEL 2011 – 4th International Symposium on Applied Sciences in Biomedical and Communication Technologies
   Barcelona (Spain)
   October 26-29, 2011

3. ABCDE Seminar 2011, ERCIM
   Berlin (Germany)
   November 10-11, 2011

IV – RESEARCH EXCHANGE PROGRAMME (REP)

1. CWI (Centrum Wiskunde & Informatica), Amsterdam, the Netherlands
   Department of Algorithms, Combinatorics, and Optimization
   Prof. Guido Schäfer
   Date: January 22-28, 2011

I visited the department of "Algorithms, Combinatorics, and Optimization" and I had a presentation during the visit. We had some meetings and discussions on application of optimization techniques for networking i.e. application of Game theory in networking.

2. School for Computer and Communication Science, EPFL, Lausanne, Switzerland.
   Distributed Information Systems Laboratory (LSIR),
   Prof. Karl Aberer (Head)
   Date: May 1-8, 2012

I had the opportunity to visit LSIR in EPFL. We had several meetings to have more information about the research activities. The idea of reliability checking in networking was the main topic. Moreover, I visited Prof. David Atienza Alonso in the Embedded Systems Laboratory (ESL). He kindly presented the activities of his group on wireless body sensor networks (WBSN).