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ON BRAIN AND IMMUNE NETWORKS AND AN APPLICATION

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Abstract. Networks are ubiquitous in nature. Studying interconnected networks is an important task. Here Some principles of immune systems are used in internet safety. Objectives of brain network are stated and one of their consequence is given.

1. Introduction

Networks are ubiquitous in nature. Recently developments have shown clearly that most realistic systems do not work in isolation, e.g, epidemics [1], financial crises, internet security, cascade failure etc...
The appearance of the concept of adaptive graph[2] where the topology of the network changes with the dynamics has made networks more relevant to real systems. An effective formulation for such systems is given in [3].
Most systems are connected. The total blackout of Italy 2003 has shown that the behavior of interdependent networks [4] differs significantly from independent ones. Therefore studying interconnected networks is an important task. Moreover it is important to study realistic systems e.g. power stations, economy and biology.
Here we study brain and immune networks.

2. Brain network:

Recently [5] has discussed optimization in brain network. The objectives of the brain network are:
Minimize cost.
Maximize functional repertoire.
Efficient global communication.
Third objective implied that brain network has small world network structure[6].

3. Basics of the immune system [7]-[8]

(1) Minimize damage to the body.
(2) Efficient use of the resources of the body .

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These can be translated to risk management if one treats antigens (worms , viruses , bacteria etc...)as computer viruses , terrorists etc.... These objectives lead to the following:

(1) The immune system is non-centralized to be able to identify nearly all antigens.
(2) Most immune effectors have more than one function , It is known [9] that this property of multi-functional and multi- pathway ensures the flexibility of the immune network.
(3) Evolution is an intrinsic property of the immune system. This is exactly the property Lacking in (say) anti-computer viruses programs[10].

4. Applications to internet security

Now the above conclusions are applied to an overview of internet security.

(1) Internet security cannot be solved locally (e.g. by one organization) hence "collective efforts" are needed. It begins by individual's PC antivirus programs. Then similar organizations e.g. universities, hospitals etc.. should share information about computer viruses. This should be extended to international cooperation between similar organizations. Also internet search engines can play a significant role in detecting suspicious sites.
(2) To be solved it needs a long time hence evolution and diversity in solution strategies have to be taken into consideration. So far this is an open problem since to the best of my knowledge antivirus programs are static.
(3) The same objective should be done by more than one method to ensure the resilience of the system.
(4) Decentralization is required to be able to identify the different types of risk.

The problem of immune motivated internet security has also been discussed in[11].

5. Equilibrium and stability of fractional order system on network[12]

The fraction order dynamical system on general network takes the form

$$D^\gamma y_i = f_i(y_i) + \Sigma_{j\neq i} A_{ij}(t) g_{ij}(y_i, y_j). \tag{1}$$

Averaging on the network time dependence one gets

$$D^\gamma y_i = f_i(y_i) + \Sigma_{j\neq i} \bar{A}_{ij} g_{ij}(y_i, y_j). \tag{2}$$

The solution of equilibrium is given by

$$f_i(y_i) + \Sigma_{j\neq i} \bar{A}_{ij} g_{ij}(y_i, y_j) = 0,$$

and it is stable if all the eigenvalues of the matrix

$$C_{ij} = [\frac{\partial f_i}{\partial y_j} + \Sigma_{j\neq i} \bar{A}_{ij} \frac{\partial g_{ij}}{\partial y_i}]\delta_{ik} + \bar{A}_{ik} \frac{\partial g_{ik}}{\partial y_k}$$

satisfy $|\arg(\lambda)| > \gamma\pi/2$, where C_{ij} is calculated at equilibrium.

As an example we present a coupled map lattice model[13] modified to fractional order

$$D^\gamma y_i = f_i(y_i) + g(y_{i+1}) + g(y_{i-1}) \tag{3}$$

The solution of equilibrium is given by

$$f_i(y_i) + g(y_{i+1}) + g(y_{i-1}) = 0,$$

and the stability of the above equation is given by the condition $\mid \arg(\lambda) \mid > \gamma\pi/2$ where for the equilibrium of the homogeneous case y_i=y_{eq} $\forall\ i$

$$\lambda = f'(y_{eq}) + 2g'(y_{eq}) \cos 2\pi r/n,$$

where r=$0, 1, ..., n-1$.

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