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On balance control model of intelligent security system

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ABSTRACT

The increasingly accelerating pace of urban construction and urbanization result in rapid population expansion in cities as well as more disasters and accidents with worse effects caused by human or/and natural factors, which pose serious threats and destruction to the sustainable development function of cities, and make unprecedented challenge to the public security of cities, esp., those so-called Smarter City, whose public security are under the crises of complexity and dynamic characteristics. In this thesis, a balance control mechanism model of intelligent security system is established, based on the analyses of the connotation and system framework of intelligent security, which is, then, used in analyzing a city's balance control mechanism intellectually in accordance with its actual state of urban security, to establish an artificial neural network model of the balance system with the reference of the ecological theory of self-organizing and self-adapting, so as to provide emergency treatment ways for urban crisis. In addition, a basic framework for constructing a dynamic, adaptive, distributed, diversified and multi-level security system is proposed by taking Hill function calculating expression as an example, which helps to lay a solid theoretical basis for the formation of stabilized economy, society and environment in cities, and a comprehensive scheme is proposed to fulfill intelligent security in Smarter cities, which was proved feasible theoretically. Also, the balance control mechanism model of intelligent security system can be seen as a base to support the futural public security network platform of urban system in Smarter cities.

KEYWORDS

Macroporous resin; Laccase; Immobilization; Mathematical model.

INTRODUCTION

Smarter City is the product of urban development to the senior stage, whose management involves an open environment in which both subject and object of city are likely to have weaknesses of different levels that tend to bring corresponding risks, and security mechanism should be established to overcome weaknesses avoid possible risks and ensure the construction of Smarter urban smoothly. Now intelligent security are researched and applied in wider fields than ever before, and people come to realize that they can hardly imagine to build safe and intelligent urban environment with traditional theory and technology on city security only, and to keep cities' security indicators in a relatively balanced state, it is imperative to seek the help of innovated city security concept and new information technology. In this thesis, neural network theory and immune system theory are used in discussing the urban public security systems' construction and development for Smarter cities, which, from a brand new prospective, reveals the characteristics in the composition, operation, etc. of intelligent public security system, and provides a reference for further research on public security immune and balance theoretically and technically.

CONNOTATION AND SYSTEMATIC FRAMEWORK OF INTELLIGENT SECURITY

Intelligent security is supported by various technologies, such as Internet, Internet of things, big data, cloud computing, etc., so that it can get all the information on a city's security and its subsystems can share resources and achieve collaboration with each other to establish a unified public security network system, as well as its emergency response mechanism. If crisis occurs, different emergency departments will make jointresponse, under unified scheduling and unified commanding. Thus intelligent management on public security, whose core is to be effective in forecasting and warning by integrating and processing of information, highly resource integration, and to be efficient and intelligent in emergency treatment through resources' integration and linkage.

(1) Intelligent prediction and monitoring and effective avoidance of potential security hazard are achieved with the help of widely-used IT and innovated systems and mechanisms.

(2) Integration security management is achieved by integrating all necessary resources.

(3) Flexible processing is achieved because intelligent public security management is of a certain flexibility as well as procedural and standard nature.

THE CONSTRUCTION OF BALANCE CONTROL MECHA-NISM OF INTELLIGENT SECURITY SYSTEM

Intelligent security crisis balance control

Intelligent security crisis monitoring balance mechanism is constructed on the model of ecology theory aiming to do dynamic real-time monitoring work, to regulate and balance urban security state automatically, to serve thecity's public security protective ability to resist crisis and to achieve its self-protection and smoothsuccession to the largest degree. With the rapid development of economy and society and the accelerating of urbanization process, some new problems arise in city's public security, with wider ranges covered, deeper impact left, multiple factors involved, and greater suddenness shown, etc., while the construction of urban public security management ability is lagging behind comparatively, which can be regarded as one of the unstable factors influencing the harmoniousness in city's development.

Under this background, to strengthen the management of urban public security monitoring and balance control, especially the construction of intelligent security system, can not only provide support important to constructSmarter cities, but also lay a solid foundation to maintain a sustainable development of economy and societywith the development of Smarter cities.

Analysis on themotivators of intelligent security balance control system

The intelligent security balance control system is a complex organic system with its self-perception and self-adaptability. It is on the brink of chaos, or in the critical state, driven by its internal function mainly and moving in a complicated,orderly and self-organizing way. In general sense, balance means remaining in a constant stationary state for a fairly long time, while in a Smarter City, security balance is a dynamic security balance collaborating the linkage of all supporting technologies and the interaction of all subsystems in the city, which is only in a constant balance of state distribution, and is defined as “stable state” in physics. Traditional city security management always needs human intervention in its working processes from monitoring, prevention, to emergencytreatment, and is of setbacks, such as less accuracy, inadequate intelligent degree in security system, slow response, etc. In fact, the threat a city confronted to is often a concurrent one, i.e. all subsystems of the city will be affected at the same time, so it is necessary to make quantitative description to the hazard and its consequences when working on security planning and implementation.

Using Artificial Neural Networks, Artificial Immune systems and GA， we can analyze the balance control mechanism of a city’s intelligent security system and simulate the balance state of the system’s neural network efficiently. The authentication of intelligentsecurity balance system’s dynamic monitoring ability and its adaptive, distributed, diverse and multi-level balance control ability, as well as the construction of security equilibrium model and balancer model, provide a strong support theoretically to defense the crisis intrusion from urban security systems.

MODULAR INTELLIGENT SECURITY SYSTEM IMMUNE MODEL

The major concern of modular intelligent security system immune model lies in the self-repair and self-balance properties of urban system, which enable the system to keep on working normally even under threat so that the city can still enjoy its due services.

Figure 1 is the topology structure of the processing units constructed the modular intelligent security system immune model, which consists of two virtual networks, the immune network system and the multi-layer artificial neural network.. Immune network system consists of local area and metropolitan area, so does multi-layer neural network.

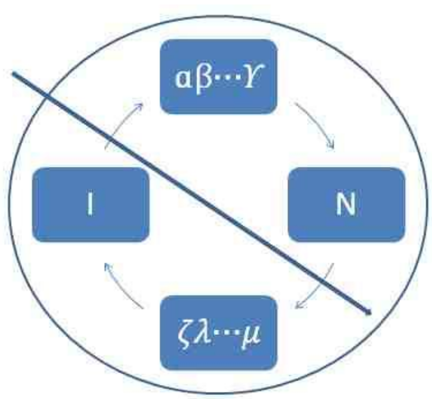

Figure 1 : Diagram of public crisis processing structure

The processing unit of intelligent security immune neural network model (see Figure 1) is composed by local neural network N and local immune network I, while intelligent security immune neural network consists of data processing unit and data sensing unit (see Figure 2).

In the intelligent security systems, there is a negative feedback loop between of antigen and immune factors, whose effect can be expressed in Hill function, which was introduced into the immune response by Kaufman and Hepburn Yu, as follows:

$$F_i^+(x_j) = \frac{x_j^n}{\theta_{ij}^n + x_j^n} \quad (1)$$

The above is an increasing function on“j ”, describing the variable x_i promoted or activated by variable“ x_j ”, in which “n” is Hill coefficient, which influences the curve gradient of function; “θ_{ij}” isthreshod value constant, whose threshold values and the sum are all related to. In contrast to it, another type of the function, a decreasing function describing the variable suppressed instead of promoted or activated by variable is introduced.

$$F_i^-(x_j) = \frac{\theta_{ij}^n}{\theta_{ij}^n + x_j^n} \quad (2)$$

It is used to describe suppression of immune factors on antigen.

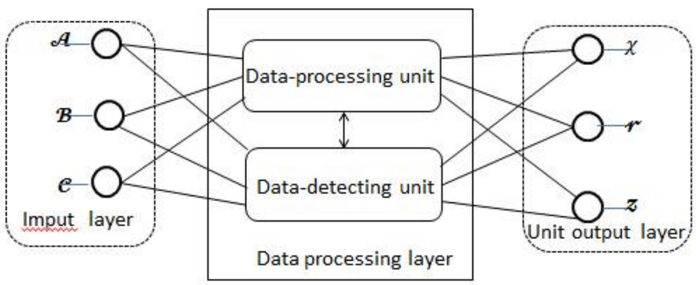

Figure 2 : Intelligent security immune neural network model

INTELLIGENT SECURITY SYSTEMEQUILIBRIUM MODEL

Urban system is a dynamic network environment system composed of multiple subsystems. According to the theory of immune network cite immune network theory, before antigen stimulation, the system is in a relatively safe and stable state. That is to say, the city’s intelligence security crisis balance system can effectively process some antigen effectively and suppress other antigen it cannot process, by which the system reach a stable balance. However, new antigen keep on entering the system, which break the balance and activate the immune network system within the system, then those suppressed subsystems begin to look for initial equilibrium state automatically, and will soon fulfill self-regulation and self-mending. Thus, the urban functions and corresponding services get restored, so does urban security index of equilibrium in the new city.

Definition 1. Modular balance base is the most original vector set of network to process security balance, whose composition is shown in formula (3),and different moduleshave different vector sets.

Definition 2. Security equilibrium state is the quantitative state of security, or the quantitative measureof urban network system regained balance after being threatened.

Definition 3: “A_I ” Applying strategies and fitness function to antigen respectively, if the income value were more than balance threshold value, network is in the state of suspicious non-equilibrium“i”, and network is in the state of suspicious equilibrium.“i”

Antigen of different features will activate different processing units, and different processing units correspond to different base sets, so in using competitive algorithm, we should choose processing unit correctlyby classifying antigen before selecting and calculating the concentration of the antigen and antibody at the same time. Assuming that strategy set are:

$$\{(a_{11}, f_{11}), (a_{11}, f_{11}), \cdots, (a_{1k_1}, f_{1k_1})\}; \{(a_{21}, f_{21}), (a_{22}, f_{22}), \cdots, (a_{2k_2}, f_{2k_2})\} \cdots$$
$$\{(a_{m1}, f_{m1}), (a_{m1}, f_{m1}), \cdots, (a_{mk_m}, f_{mk_m})\} \quad (3)$$

Apply rules to antigen, and calculatethe matching probability and then the vector sets with matchingprobability of: "$P_i = \max_{1 \; i \; m}(\text{match}(A_i, \; A))$", to theantigen.

$$\{a_{11}, \; a_{12}, \; \cdots, \; a_{IK_I}\} \quad (4)$$

Applying fitness function G(X) tothe vector setsasfollows:

$$f_I(a_{I1}, \; A) = \{b_{11}, \; b_{12}, \; \cdots, \; b_{1t_1}\}, f_I(a_{I2}, \; A) = \{b_{21}, \; b_{22}, \; \cdots, \; b_{2t_{21}}\}$$
$$f_{Im}(a_{Im}, \; A) = \{b_{2m}, \; b_{2m}, \; \cdots, \; b_{mt_{m1}}\} \quad (5)$$

Then compute function value is:

$$G(b_{1j_1}, \; b_{2j_2}, \; \cdots, \; b_{mj_m}) = \omega_{Ij}, \; 1 \; j_1 \; t_1, \; 1 \; j_2 \; t_2, \; \ldots, 1 \; j_m \; t_m.$$

Select the vector set satisfying: $\omega_{ij} \; \theta_j$ setting it $\{b_{1j_1}, \; b_{2j_2}, \; \cdots, \; b_{mj_m}\}$ as $\{b_{1p_1}, \; b_{2p_2}, \; \cdots, \; b_{mp_m}\}$, $\{b_{1p_2}, \; b_{2p_2}, \; \cdots, \; b_{mp_2}\}$, $\cdots$, $\{b_{1p_n}, \; b_{2p_n}, \; \cdots, \; b_{mp_n}\}$; "$\theta_j$", and the relevant security threshold corresponding to system vector base set. $\{a_{11}, \; a_{12}, \; \cdots, \; a_{IK_I}\}$

Given concentration calculation formula:

$$A(u) = \frac{1}{N}\sum_{j=1}^{N} c_{Ij} \quad \textbf{And:} \quad c_{Ij}\begin{cases} 1 & \omega_{Ij} \; \theta_j \\ 0 & \omega_{Ij} < \theta_j \end{cases}, \; j = 1, 2, \; \cdots, \; N \quad (6)$$

In which: N is the number of antigen (antibody), "θ_j" is the related security threshold corresponding to city security factor vector base set $\{a_{11}, \; a_{12}, \; \cdots, \; a_{IK_I}\}$, Antigen concentration can be calculated using the formula **(6)**.

Set : $P_{max} = \max_{1 \; i \; m}(\text{match}(A_i, \; A))$, $P_{min} = \min_{1 \; i \; m}(\text{match}(A_i, \; A))$, assuming there is a certain vector basis set with a + probability greater then set it T, to calculate affinity of antibody, and recycle formula to calculate the concentration of antibody concentration.

With plenty of different bases and different fitness function G corresponding to different base sets, the above is a dynamic quantity, the following competition algorithm is used to determine the antigen processing units:

$$U(0,1) = \begin{cases} F_i^+ m_k & F_i^+ m_k - l_k > \bar{x}_k \\ F_i^+ m_k & F_i^+ m_k - l_k > \underline{x}_k \\ m_k & \text{otherwise} \end{cases} \quad (7)$$

In which: l_k is the new antigen concentration; m_k is the optimal concentration of antigen in different processing units (the antigen concentration in security balance); $S = [\bar{x}, \; \underline{x}]$ is the concentration domain of the antigen processing unit; F_i^+, F_i^- is the Hill functional (1) (2). Choose the U and processing units most close to the concentration field values, which can determine the security threshold, parameters of the processing units, as well as the Hill function of antigen and antibody promotion and suppression

REAL-TIME EQUILIBRIUM ANALYSIS MODELOF INTELLIGENT SECURITY SYSTEMS

In Real-time analysis model of equilibrium of this paper, using x_1 represents the concentration of the antigen vector "i", x_2 represents the concentration of antibody vector j, the model is as follows:

$$\begin{cases}\frac{dx_1}{dt} = k_1 f_1(x_2) - a_1 x_1 \\ \frac{dx_2}{dt} = k_2 f_2(x_1) - a_2 x_2\end{cases} \quad (8)$$

$k_i(i = 1, 2)$, $f_i'(\infty) = 0(f_i'(\infty) = 1)$, $(i = 1, 2)$, in (8) Satisfying initial value, in (8) : The sum of parameters are as normal constant, which meets the following conditions, $x_1(0) = x_1^0$, $x_2(0) = x_2^0$, type (8) in the initial value of the content, the first equation describes the evolution process of antigen concentration, using Hill function to describe the suppression of antibodies to the input rate of antigen, and parameter represents antigen loss rate, consists of three parts: the removed part from the immune system, the transited part to another phenotype, the naturally dead; the second equation describes the evolution of the antibody, whose input rate is affected by antigen.
in Type (8) the vector field is

$$DF = \begin{bmatrix} -a_1 k_1 f_1(x2) \\ k_2 f_2(x_2) - a_2 \\ \end{bmatrix} \quad (9)$$

If choose, Type (8) is a monotonous system. From the form of vector field in it, the type (8) is an irreducible matrix, so the type (8) is an irreducible monotonous system. Atheorem on analyzing the existence and stability of the equilibrium of type (8) is as follows:

Theorem 1 (8) the number of equilibrium is an odd number, and there is a partial order between them and every odd numbered equilibrium is asymptotically stable, while the every even numbered equilibrium is unstable, which prove that the right end of type (8) is 0, the relation about can thus be obtained:

$$x_1 = \frac{1}{a_1}\left(k_1 f_1^o \frac{k_2}{a_2} f_2\right)(x_1) ; \quad x_2 = \frac{1}{a_1}\left(\frac{k_2}{a_2} f_2(x_1)\right) \quad (10)$$

Therefore, the equilibrium f type (8) is in a nonnegative solution with type (11).

$$\Gamma(x_1) \equiv \frac{1}{a_1}\left(k_1 f_1^o \frac{k_2}{a_2} f_2\right)(x_1) = x_1 \quad (11)$$

Now look at mapping. $\Gamma: [0, \infty) \rightarrow [0, \infty)$。

From whose nature, it is easy to verify: $1 < \Gamma(0) = \frac{k_1}{a_1} f_1\left(\frac{k_1}{a_1}\right) < \frac{k_1}{a_1} = \Gamma(\infty)$ (12)

And $\Gamma'(0) = \frac{k_1}{a_1} f_1'(x_2) \frac{k_2}{a_2} f_2'(z)$ (13)

So we have to make things simpler, assume: if $\Gamma'(z^*)=z^*$, $\Gamma'(z^*) \neq 1$. According to the fixed point theory, z^* is an isolated fixed point of Function Γ, whose fixed point index should satisfy: $v(\Gamma, z^*)$

$$v(\Gamma, z^*) = \begin{cases} +1 & \text{if } \Gamma'(z^*) < 1 \\ -1 & \text{if } \Gamma'(z^*) > 1 \end{cases} \quad (14)$$

Available from type (2-12) (2-13), there are $z^1 < z^2 < \cdots < z^h$, odd numbered fixed points and

$$v(\Gamma, z^r) = \begin{cases} +1 & \text{when } r \text{ is odd} \\ -1 & \text{when } r \text{ is even} \end{cases} \quad (15)$$

while the corresponding in type (8) there are equilibrium points

$$E^r = (x_1^r,\ x_2^r),\ r = 1, 2 \dots,\ h \quad (16)$$

in which: $x_1^r = z^r,\ x_2^r = \frac{k_2}{a_2} f_2(z^r)$

Since the function is a strictly decreasing function, type (8) equilibrium arranges in thefollowing order: $E^h < K_m E^{h-1} < K_m \dots < K_m\ E^1$

For any balance in type (9), it is easy to prove that if and only if the determinant is positive, the assumption is met, in which, $s(A) = \max Re\lambda$ but ergodic matrix spectrum, namely the Det> 0, the polynomial of points are as follows:

$$\lambda^2 + (a_1 + a_2)\lambda + a_1 a_2 - k_1 k_2 f_1'(x_2) f_2'(x_1) = 0 \quad (17)$$

From the characteristic polynomials in equilibrium state (2-16), s≠0, so if "E^r"is notin an asymptotically stable, at least one value is a real component, so it is unstable.
By assuming that $\Gamma'(z^r) \neq 1$, or $\Gamma'(z^r) > 1$, or $\Gamma'(z^r) < 1$,

That is:(a) $v(\Gamma,\ z^r) = +1 \Leftrightarrow |(DF(E^r))|$>0, and s < 0 guarantees the asymptotic stability of the equilibrium state;(b) $v(\Gamma,\ z^r) = -1 \Leftrightarrow |(DF(E^r))|$<0<0, and the equilibrium state is not stable.

Since type (8) the existence and stability of the equilibrium state is consistent with the mapping, it is accessible from the nature of the mapping (13) and (15) that the odd numbered equilibrium is asymptotically stable, and the even numbered equilibrium is unstable, period. If Theorem 2 represents the attraction domain of equilibrium, it is open and dense in the $\bigcup_{r \in odd} B(E^r)$ and R^2, if the number of equilibrium h=1, E^1 in Θ (1, 1) is a globally attracted, as certificated in type (2-17), and assuming: In which, A, B are two intersection coordinate points of the following equations.

$$k_1\tau_1 - a_1 y_1 = 0,\ k_2\tau_2 - a_2 y_2 = 0\ ,\ \Theta(\tau_1\tau_2) = [0,\ A] \times [0,\ B] \quad (18)$$

For any fixed, from $f_1 \in [0,\ 1]$ we know that on the boundary of $\Theta(\tau_1\tau_2)$ are:

$\frac{dx_1}{dt} = k_1 f_1(x_2) - a_1 x_1 \leq k_1\tau_1(x_2) - a_1 A = 0$ And, at that time, similar conclusion can be got at the time of 1.

To sum up, the system mapping into its interior along the border, forms a positive invariant set, and, for each fixed time(I = 1, 2), each solution of the system will enter and stay there inside, period.

Theorem 3. Assume $B(E^*)$ to represent the attraction domain of equilibrium, the following formula established:

$$\{x: E^2 \leq Km^{x, x \neq E^2}\} \subset B(E^1),$$
$$\{x: E^{r+2} \leq Km^x \leq Km^{E^r},\ x \neq E^r,\ E^{r+2}\} \subset B(E^{r+1});$$
$$r = 2,\ 4,\ \cdots,\ h-3,$$
$$\{x: x \leq Km^{E-1}, x \neq E^{h-1}\} \subset B(E^h),$$

Using analyses of theorem 1 and 2 can prove theorem 3, period.

When the Hill function coefficient n = 1, the system has three equilibrium t most. According to theorem 1, the two odd numbered equilibriums are stable, from mutual inhibition of the relationship between antibody and antigen, it is not difficult to know that a system may stay in a steady state, namely, with low concentration of antigen but high antibody concentration, or tend to be in another steady state, namely with high antigen concentration but low concentration of immune factors. from theorem 2 we can get some details of equilibrium attraction domain, namely, still assuming Hill function coefficient n = 1, from the first conclusion of theorem 2 we know the security of the antigen is higher, while from the last conclusion of theorem 2, the security of the antigen is low, so when the equilibrium state of antigen loads is a critical value, the security of the antigen is uncertain.

BALANCE FUNCTION MODEL OF SECURITY SYSTEM

Type (7) is used to calculate antigen concentration and antibody concentration, and competition algorithm is used to determine antigen processing units, which can, in turn, determine that it is their corresponding equilibrium analysis model type (8) process antigen (different processing units have different parameters), the equilibrium state analysis model (8) can determine system has three equilibrium states at most, in which the relations between roles of antibody and antigen in described in the following algorithm:

(a) Same as Type (8).

(b) If the concentration of antibody is higher, the city system is determined a relatively safe balance; Or if the concentration of antibody is lower, the network system's security is surely not balanced.

(c) As to the unsafe equilibrium of urban system, from the figure of activated processing units and processing units (3.3), the urban system status is determine: unsafe state and suspicious state

(d) Repeatedly apply type (2) to unsafe state and suspicious state, the outcome function value is still functioned, until make the system back into balance.

Step (c) to (d) we finally get the concentration of antigen as a newly produced antibody, and save concentration of new antibody corresponding to antigen.

CONCLUSION

Balance control mechanism model of the intelligent security, as an instance of a city safe balance system model, though not perfect enough, implement the application value of integrating some key technologies, including proposing an overall structures of thought, studying intelligent security in view of artificial neural network, immune system and mechanism of genetic algorithm research, constructing a multilayer, modular, dynamic, self-adaptive and distributed urban intelligent security balance control system, which can be expanded to realize a real-time data-based urban information correlation analysis technology, high performance event processing technology, mass event analysis technology and information visualization technology, etc. In this thesis, by defining the concept of intelligent security balance system, the mathematical model of the antigen and antibody equilibrium state detection are established, classification is made on intelligent security balancers through surface detection processing, balance judgment is made on unsafe state, and finally, using neural network to determine the security status of a city, using the inhibiting function and fitness function of genetic algorithm to help citiesunder threat to regain security balance state, so as to provides a good theoretical basis for the stability of city economy, society and environment and a comprehensive scheme for the intelligent construction ofurban security, which is proved feasibletheoretically. Intelligent security balance mechanism provides a strong supportfor the urban public security management theory.

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