International Journal of Control and Automation
Vol.7, No.2 (2014), pp.351-362
http://dx.doi.org/10.14257/ijca.2014.7.2.31

Research on the Model Mechanism and Decision Management in the Evacuation Configuration Process Control

Li Wei and Zhang Ying

College of Information Science & Engineering, Chongqing Jiaotong University, China

lwcqcn@sina.com.cn

Abstract

The rail transportation has occupied an important position in the development of the modern city transportation, for more fast and convenient passengers evacuation under emergencies, an evacuation process control system is designed based on a cooperative scheme, next relevant model mechanisms and configuration structure patterns are discussed, and moreover an evacuation knowledge decision flow is analyzed by adopting a knowledge management pattern, finally, the helpful efficiency of this method has been tested and verified with improved and better services.

Keywords: *Evacuation, Knowledge decision, Rail transportation*

1. Introduction

In recent years, it plays a more important role of a rail transportation hub which is as a large crowd distribution facility, along with the construction and operation of large-scale city rail projects in some huge cities, such as Beijing, Shanghai, Chongqing. Moreover in most of domestic rail transportation hub stations, more complexly internal structure are designed, especially in some large traffic hub transfer station, the passengers' gathered degree is higher, there exist mutual influence relationships among different emergency evacuation flows, various evacuation devices are relatively close, and real-time interactions among emergency facilities are lack, so for avoiding a little negligence with serious consequences, it is urgently needed of a timely evacuation of gathered passengers. But fatally, there are relatively few design standards on passengers' evacuation under emergencies in the existing design specifications on rail traffics, and which are also not fully suitable for current reality, for example, there are little considerations on emergency evacuation capacities of key evacuation bottleneck facilities, such as escalators, provisions, ticket gates, thus which are very difficult to fully meet real conditions of the passenger evacuation design in the rail transportation hub.

Thus it is a relatively new and important subject under emergencies in a relative closed space with a high passenger population density, that how to take some reasonable technical and management measures for achieving a quicker and safer personnel evacuation of the more open area. In current evacuation research, about 50 kinds of evacuation models have been established or are developing, which are mostly a kind of microscopic simulation based on the cellular automata model, and also some model algorithms on some connected people flow, population density and the average flow velocity have partly been formed, for example, Pursals discussed an optimal building evacuation time with a consideration of evacuation routes [1], Candy analyzed the waiting time in emergency evacuation of crowded public transport terminals [2], Dongdong Liu has researched on the pedestrian

ISSN: 2005-4297 IJCA

safety evacuation at transportation hub based on conformity psychological effect [3], Dandan Ding made a detailed study on the transfer and connection of huge passenger flow at urban transit hub [4]. But there are still less strategies and methods with a real-time cooperative evacuation guidance based on the current population distribution and passenger emergency evacuation capacity, so for improving the evacuation efficiency, it is not enough extensively and deeply studied to how to achieve a reasonably dynamic and synergistic induction under emergencies by use of a more optimal distribution of passenger evacuation path measures.

2. Evacuation Model Constructions

2.1. Relevant biological mechanism briefs

The co-evolution concept firstly came from the biology, this research began in the early nineteen nineties [5-7], the biological immune system is a kind of typical co-evolution biological systems against external harmful substances. In the past research [8-11], it has been partly presented that all kinds of immune molecules, immune cells and organs are in an adaptive alliance with a cooperative target and dynamic evolution to promote the biological immune system constantly to be in an evolutionary and defensive behaviour, and to construct a cooperatively evolutionary and adaptive relation among the immune system, the biological individual and surrounding environment, by this, biological individuals are well protective on normal life activities in the complex, dangerous and harmful environment. From the engineering point of view, there have many interesting and enlightening features to various researchers in different domain, such as the immune learning, immune adaptation, immune co-evolution, and immune self organization.

Figure 1 is a simple description of immune response [12], A_g, A_b, A_p, B, B_m, T_h, T_s, and T_c represent the antigen, antibody, antigen-presenting cell, B cell, memory B cell, helper T cell, suppressor T cell, and cytotoxic T cell, respectively. Immune cell interactions allow the immune system to have a very strong compatibility with the environment: a new kind of antigen evolves and produces new B cells; antigens increase, and A_b, B, and B_m cells also increase, otherwise, they are reduced. Immune cells already possess general characteristics of intelligent agents in essence, and an immune system forms one distributional and autonomous multi-agents system.

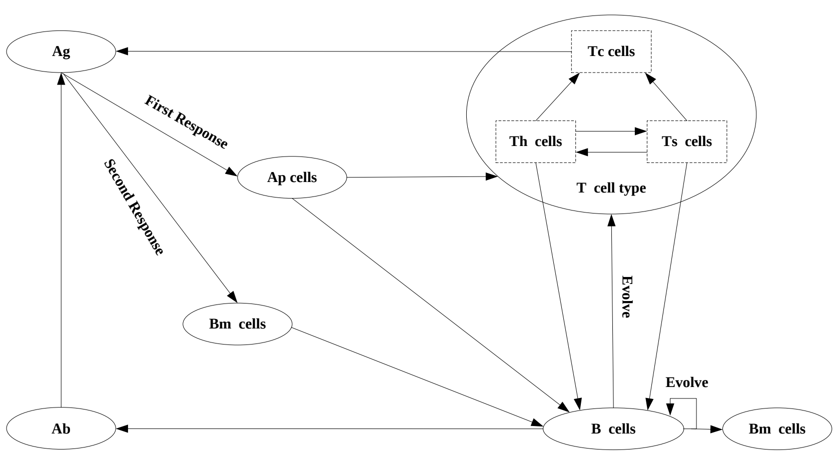

Figure 1. Process of immune response

2.2. Nature-inspired evacuation models

The process of virus recognition by the immune system is similar to the evacuation configuration process control. In this research on passengers' evacuation problems inside the city rail transportation hub, in order to reduce the delay time on the passenger emergency evacuation, the special individual, the whole crowd, traffic control facilities are cooperatively and dynamically integrated into a evacuation system by the use of this dynamic biological cooperative scheme. On the base of a real-time monitor of all traffic facilities with personnel flows and an analysis on the behaviour characteristics of all passengers in this emergency evacuation process, all neighbouring evacuation induced signals or facilities in this rail transportation hub area can be connected into the cooperative evacuation alliance, thus a designed kind of dynamically cooperative relationships can be constructed and the special evacuation guidance decision can be made through this target cooperation and dynamic evolution, a better adaptive ability of the emergency evacuation guidance system can be obtained through this constantly dynamic self-learning and co-evolution, and the directional induction effect on the passenger emergency evacuation in the specific area may be strengthened, which can effectively adapt to the dynamic change of the emergency evacuation environment and demands for rail transportation hubs, reasonably provide corresponding emergency evacuation routes for the passenger staff, and obviously improve the emergency evacuation capacity ability of rail transportation hubs.

Various immune cells have the same characters in the essence with intelligent agents, so an evacuation process control system inspired by relevant immune mechanisms can be constructed using intelligent agents with a number of interactions for passenger evacuation tasks. In the designed evacuation process system a few evacuation agent groups (EAU) [12] with different preferences are adopted for constructing or creating a mutual cooperation among different types, and all similar types are in some exclusion. This feature is very similar to the promotion and inhibition relationship among special immune antibodies. If a passenger evacuation task is viewed as an antigen, according to the fitness evaluation program and through evolutions of existing EAU agents, a new EAU may be created to improve adaptabilities to complex evacuation tasks in an evacuation process control system.

Each agent in the EAU works as a highly autonomous, real-time modular unit which is inspired by the immune response mechanism of transferring information. Each EAU can be constructed by the use of various functional agents, including a detection agent, a preference agent, a decision agent, a management agent, a memory agent, and a cooperative evolution agent, the internal structure of an EAU is shown in Figure 2.

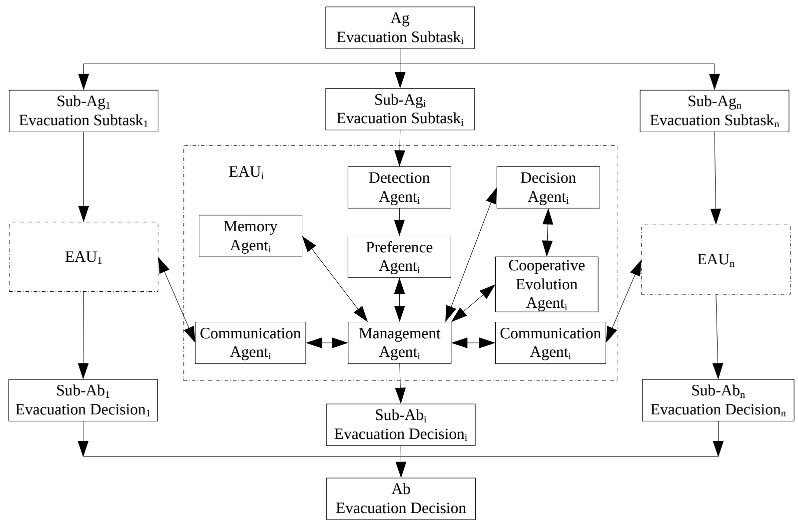

Figure 2. An EAU structure

A detection agent is an integrated state agent identification system that is responsible for drawing present antigen characteristics from their own information to form characteristic modes about antigens. A preference agent is in charge of this EAU's special evacuation preference, including its evacuation symptoms, its evacuation cooperative factor, its evacuation preference factor and its evacuation influence factor etc. A management agent is an administrator in the EAU that coordinates the behavior of other agents in the same EAU and obtains an overall appraisal of the present state of the EAU. A decision agent is responsible for combining all evacuation information, undertaking evacuation control decisions, and sending evacuation sub-solutions to a management agent for an overall appraisal. A cooperative evolution agent is responsible for cooperatively evolving, optimizing and adjusting what an agent possesses, such as its work patterns, its domain knowledge, its computation models, and so on, to obtain suitable antibodies for present antigens while an EAU can not solve an admitted evacuation task. A memory agent makes a duty on establishing an antibody-mode storehouse and upgrading this to strengthen a kind of faster solvable ability of passenger's evacuation in the second response form while a known antigen mode happens.

3. Evacuation Configuration Mechanism and Process

3.1. EAU reconfigured structure

In an EAU's evolutionary process, required integrated applications can be built as a functional module in this EAU, components in every EAU should be classified using six different level types: evacuation data, evacuation parameters, evacuation symptoms, evacuation states, evacuation rules, and evacuation models, whose mutual relationships among different functional components in the evacuation process control process are shown in Figure 3 [12, 13].

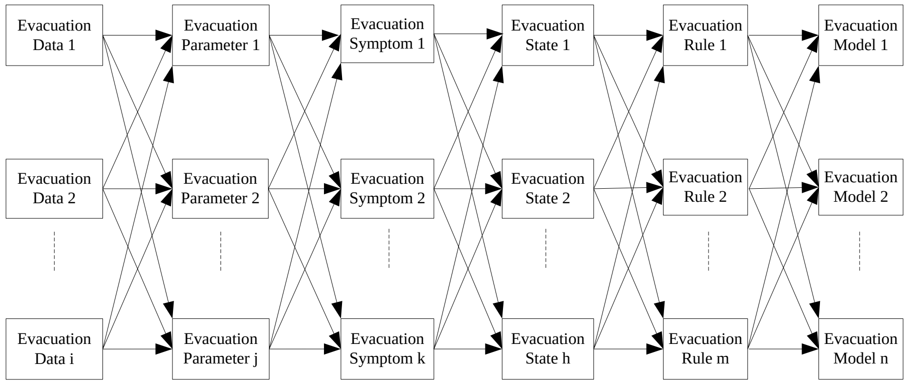

Figure 3. Evacuation components' mutual relationship

The component type of evacuation data is composed of all digital information from all participants in the evacuation environment, including all individual information, all path information, all electronic traffic equipment, and all current environment information. The component type of evacuation parameters is used to represent different fundamental and quantized evacuation data, such as the current individuals' quantity or flow data, the current path capacity data, the current temperature data, the current noise data, and so on. The component type of evacuation symptoms is applied for representing current practical evacuation parameters' value. The component type of evacuation states is used to describe the current practical evacuation parameters' value from a special evacuation participant, which is as a condition or conclusion of a regional evacuation rule. The component type of evacuation rules is composed of several evacuation states in the form of some rule's premises, a rule's conclusion, and a rule's confidence. The component type of evacuation models is constructed by several evacuation rules and in charge of some complete evacuation control decision schemes on special evacuation tasks. The component type of evacuation data, evacuation parameter, evacuation symptom, evacuation state, evacuation rule and evacuation model are relevant and not independent.

An EAU is designed in the form of a hierarchical structure of a data support layer, a common object layer, a professional layer and an application layer, and hierarchically constructed by different COM components, which can offer special services to others through different interfaces, thereby, different layers can conveniently separate changeable parts from stable parts, thus this hierarchical structure can effectively support an EAU's evolutionary process.

3.2. Cooperative agents' functional construction process

While an unknown evacuation control task is emerging, in the current EAUs' group, cooperative evolution agents will make special immune cooperative operations on some randomly selected functional agents for constructing some possible candidate sets mainly based on their cooperative evacuation preference factor, evacuation influence factor, evacuation affinity, and apply special immune evolutionary operators on these candidate sets, which includes a special cooperative evacuation preference factor, a special cooperative evacuation influence factor, a special cooperative evacuation appraisal factor, a conventional cloning operator, a conventional mutation operator, a conventional inhibition operator, and so on, finally, after calculating each selected functional agents' density and affinity, some possible immune evolving schemes from these cooperative evolution agents are implemented on selected functional agents by specially designed evolution modules in different cooperative evolution agents to reconstruct a new EAU for this current unknown evacuation task, so for this work aim, a designed functional structure [12,13] of cooperative evolution agents may be listed in Figure 4.

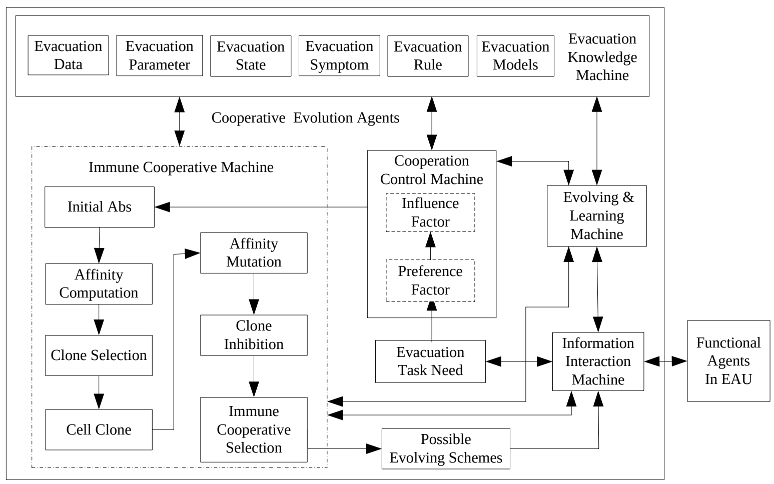

Figure 4. Cooperative evolution agents' functional structure

Based on above various components, six different ability knowledge classes can be created and logically organized of the evacuation data knowledge class, the evacuation parameter knowledge class, the evacuation symptom knowledge class, the evacuation state knowledge class, the evacuation rule knowledge class, and the evacuation model knowledge class, which are described in the form of production knowledge. While an unknown evacuation task is formed as an antigen, some adaptive EAUs as antibodies are needed to be evolved for this task, and thus their EAU's ability knowledge classes are also reconfigured by the use of existing various knowledge resources, mainly, some evacuation rule classes and evacuation model classes are asked for being reconstructed by utilizing evacuation data, evacuation parameters, evacuation symptoms and evacuation states in a designed reasoning form on a reconfigured knowledge process in Figure 5, where a numerical reconfiguration decision on evacuation rules or models can be made and achieved in the form of a reliable reconfigured knowledge transmission, based on this designed reconfigured mechanism, which may realize all credibility calculations on all activated knowledge of evacuation rules and evacuation models.

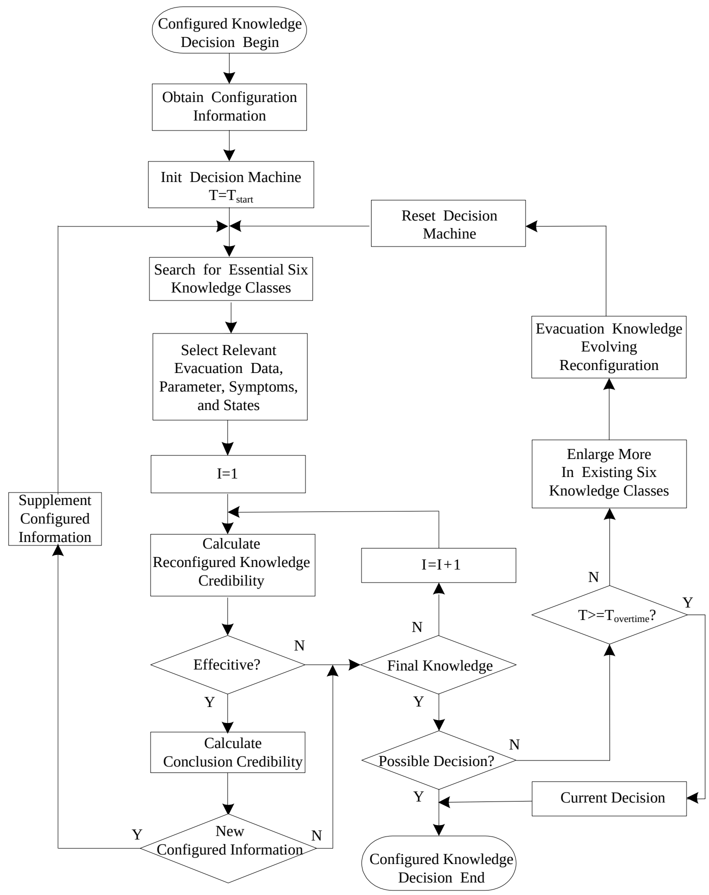

Figure 5. Evacuation reconfigured knowledge decision process

The evacuation reconfigured knowledge decision process can be analyzed as follows:

Step i, t=k, decision machines in the EAU groups are initialized, and the reconfigurable start time of T_k is set at T_{start}.

Step ii, decision machines in the EAU groups search for essential evacuation knowledge classes, select relevant evacuation data knowledge classes, evacuation parameter knowledge classes, evacuation symptoms knowledge classes and evacuation states knowledge classes and set I=1.

Step iii, decision machines in the EAU groups calculate this reconfigured knowledge credibility and its evacuation knowledge conclusion credibility, if not effective, turn to *Step v*.

Step iv, if this evacuation knowledge conclusion is new, decision machines in the EAU groups need to supplement this configured information, then turn to *Step ii*, otherwise, turn to *Step v*.

Step v, if this reconfigured knowledge is the final knowledge, decision machines in the EAU groups evaluate whether some possible evacuation reconfigured knowledge decisions have been made out, then turn to *Step vii*, if not the final, I=I+1,turn to *Step iii*.

Step vi, some possible evacuation reconfigured knowledge decisions are still not achieved by decision machines in the EAU groups, so if $T<T_{overtime}$, decision machines in the EAU

groups are asked to further enlarge more in existing six knowledge classes, make evacuation knowledge evolving reconfiguration and reset itself, turn to *Step ii*, otherwise, turn to *Step vii*.

Step vii, decision machines in the EAU groups may provide some possible or current evacuation reconfigured knowledge decisions for EAU groups.

3.3. Decision simulation

In the knowledge decision-making, based on the representation in the production form of evacuation reconfigured knowledge, each evacuation reconfigured knowledge may be contracted as follows: firstly, a piece of evacuation reconfigured knowledge has been up to two premises; secondly, a combinative relationship between premises is only allowed using the " AND " logic for this representation; and lastly, only one conclusion exists in this reconfigured evacuation knowledge [14, 15], thus the solving process of an evacuation configure problem can be mostly shown in the form of the knowledge decision tree, it is very suitable for using a method named by a width-first hunt, which indicates the hunt of others layer by layer from the bottom to the top of this decision tree after comparing all nodes in the bottom layer [16,17].

If there are some evacuation reconfigured knowledge as following:

ERK1: IF the current air symptoms in the 1^{rt} region are 10% worse than the normal (S1) (0.5) AND all air security equipments in the 1^{rt} region are in the normal state (S2) (0.5) THEN the current air state of the 1^{rt} region are in the 3^{rd} exception (SR1) (0.9, 0.8).

ERK2: IF the current background noise in the 1^{rt} region are 20% higher than the normal (S3) (0.5) AND all noise security equipments in the 1^{rt} region are in the normal state (S4) (0.5) THEN the current noise state of the 1^{rt} region are in the 4^{th} exception (SR2) (0.8, 0.7).

ERK3: IF the inlet flow in the 1^{rt} region is in the 4^{th} level (S5) (0.6) AND the export flow in the 1^{rt} region is in the 2^{nd} level (S6) (0.4), THEN the crowded degree is in the 2^{nd} level (SR3) (0.9, 0.8).

ERK4: IF the current air state of the 1^{rt} region are in the 3^{rd} exception (SR1) (0.6) AND the current noise state of the 1^{rt} region are in the 4^{th} exception (SR2) (0.4) THEN the 1^{rt} region is in the 7^{th} evacuation level (SR4) (0.8, 0.75).

ERK5: IF the 1^{rt} region is in the 7^{th} evacuation level (SR4) (0.4) AND the crowded degree is in the 2^{nd} level (SR3) (0.6) THEN the 1^{rt} region is in the 3^{rd} evacuation configured path (SR5) (0.9, 0.8).

In the simulation test of " the 1^{rt} region is in the 3^{rd} evacuation configured path ", which is listed in Figure 6, known initial conditions may be listed as, " the current air symptoms in the 1^{rt} region are 10% worse than the normal " is with an initial credibility of 0.9, " all air security equipments in the 1^{rt} region are in the normal state " is with an initial confidence of 0.8, " the current background noise in the 1^{rt} region are 20% higher than the normal " is with an initial credibility of 0.9, " all noise security equipments in the 1^{rt} region are in the normal state " is with an initial credibility of 0.9, " the inlet flow in the 1^{rt} region is in the 4^{th} level " is with an initial credibility of 0.8, " the export flow in the 1^{rt} region is in the 2^{nd} level " is with an initial credibility of 0.9, respectively.

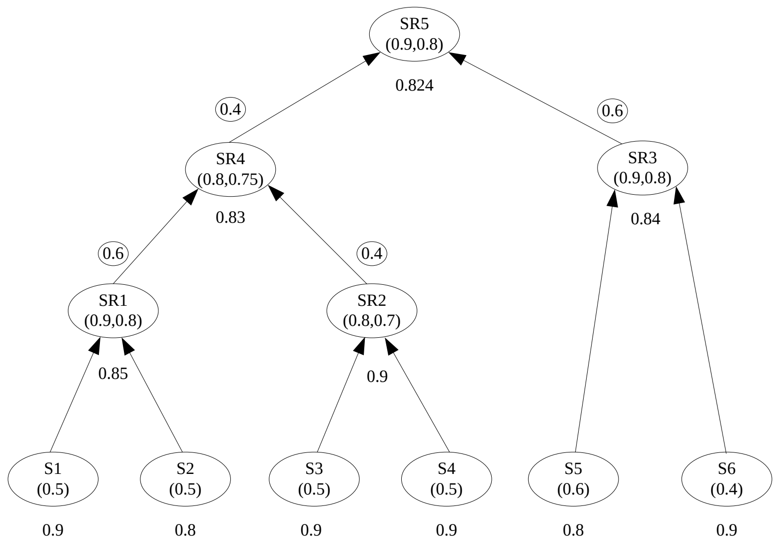

Figure 6. Evacuation reconfigured knowledge decision network

Through the " evacuation reconfigured knowledge decision " module, the reliability of an operation state is derived to be 0.824 by using previous evacuation reconfigured knowledge in the decision-making mechanism [15,16], which indicates that " the 1^{rt} region is in the 3rd evacuation configured path " occurs with a 0.824 reliability.

4. Conclusions

The rail transportation has been steadily developed in recent years, for a more fast and convenient passengers' evacuation under emergencies, an evacuation process control system is constructed by utilizing an industrial network and the Internet, and a detailed study has been presented on the configured mechanism and knowledge decision measures, which includes:

i The cooperative evacuation model is specially discussed, and some configured mechanisms on the different components in the functional agents are cooperatively analyzed for enabling various EAUs to reconfigure themselves.

ii An evacuation knowledge decision flow is designed and discussed in detail for this evacuation process control based on some configurable knowledge management patterns.

The study aims to provide an more effective method for meeting the demands of the passengers' evacuation in the rail transportation hub, this discussed and analyzed evacuation process system here may obviously improve the evacuation capacity ability of rail transportation hubs under emergencies in the simulation, which will also be helpful for promoting the automation and intelligence of the passengers' evacuation process.

Acknowledgements

This work is supported by Natural Science Foundation Project of Chongqing Educational Committee (kj130405). The authors also gratefully acknowledge the helpful comments and suggestions of the reviewers, which have improved the presentation.

References

[1] S. C. Pursals and F. G. Garzon, "Optimal Building Evacuation Time Considering Evacuation Routes", European Journal of Operational Research, no. 2, **(2009)**.
[2] M. Y. Candy, "Waiting Time in Emergency Evacuation of Crowded Public Transport Terminals", Safety Science, no. 5, **(2008)**.
[3] D. Liu, J. Liu and Y. Zhang, "The Analyses of Pedestrian Safety Evacuation at Transportation Hub Based on Conformity Psychological Effect", Fire Science and Technology, vol. 30, no. 10, **(2011)**.
[4] D. Ding and B. Han, "Study on Transfer and Connection of Huge Passenger Flow at Urban Transit Hub", Modern Urban Transit, no. 6, **(2011)**.
[5] M. A. Potter, A. Kenneth and D. Jong, "A Cooperative Coevolutionary Approach to Function Optimization", Proceedings of the Third Conference on Parallel Problem Solving from Nature, **(1994)**, pp. 249-257.
[6] M. Nerome, K. Yamada, S. Endo and H. Miyagi, "Competitive Co-evolution Based Game-strategy Acquisition with the Packaging", The Second International Conference on Knowledge-based Intelligent Electronic Systems, **(1998)**, pp. 184-189.
[7] V. D. Bergh, Frans and A. P. Engelbrecht, "A Cooperative Approach to Particle Swarm Optimization", IEEE Transactions on Evolutionary Computation, vol. 8, no. 3, **(2004)**, pp. 225-239.
[8] T. A. N. G. Zheng, T. Yamaguchi, K. Tashima, O. Ishizuka and K. Tanno, "A multiple-valued immune network and its applications", IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences, vol. 82, no. 6, **(1999)**, pp. 1102-1108.
[9] T. Hiroko, W. Yuji, I. Akio and N. Ben, "Artificial Immune System Applied to the Transportation Control", Proceedings of the Annual Conference of the Institute of Systems, Control and Information Engineers, **(1998)**, pp. 23-24.
[10] Y. Tian and P. Pan, "Application of Improved Immune Particle Swarm Algorithm in Ship Collision Avoidance", Navigation of China, vol. 34, no. 1, **(2011)**.
[11] H. Wang, G. Tan and J. Yang, "Research on Urban Traffic Emergency Detection Based on Internet of Things", Computer Science, vol. 39, no. 2, **(2012)**.
[12] W. Li, Q. Xu and L. Zhang, "Flexible Configuration Mechanism of Control and Data Management in a Process Monitor System", AISS: Advances in Information Sciences and Service Sciences, vol. 5, no. 5, **(2013)**.
[13] M. Ren, W. Zhu and S. Yang, "Component Based Architecture of Information System", Mini-Micro System, vol. 25, no. 23, **(2004)**.
[14] J. Zhou, C. Tang and Z. Xu, "Event Tree, Fault Tree, Decision-making Tree and Bayesian Network", Journal of Hohai University (Natural Sciences), vol. 37, no. 3, **(2009)**.
[15] M. Wang, N. Hu and G. Qin, "Method of Rule Extraction for Fault Diagnosis of a Helicopter Power Train Based on Incomplete Information", Journal of Vibration and Shock, vol. 30, no. 12, **(2011)**.
[16] X. Xu, J. Zhai and H. Liu, "A Knowledge-based Rough Set Model for Manufacturing Decision", Journal of South China University of Technology (Natural Science Edition), vol. 39, no. 8, **(2011)**.
[17] H. Huang, "An Approach to the Performance Evaluation of Enterprise Knowledge Management with Fuzzy Linguistic Information", Journal of Convergence Information Technology, vol. 7, no. 5, **(2012)**.

Authors

Li Wei

Li Wei received the M.S. degree in Mechatronics engineering and the PhD degree in Control theory and control engineering from Chongqing University, China, in 2002 and 2005, respectively, and now he works as a teacher in Electronic information engineering of Chongqing Jiaotong University. His current research interests include intelligent traffic computation, industry process control and fault diagnosis.

Zhang Ying

Zhang Ying received the M.S. degree in Control theory and control engineering from Chongqing University, China, in 2005, and now she works as a teacher in Electronic information engineering of Chongqing Jiaotong University, and her current research interests include traffic information process and management.