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Review Article

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A simple review of research on artificial life

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ABSTRACT

The object of Artificial life research is the natural features of life and life phenomena of artificial system or computer programming language system. The research of artificial life is accompanied by the thirteen International Conference on artificial life and growth. Twenty five years ago in September 1987,the first Artifcial Life Work shop was held at Los Alamos National Laboratory and the subsequent Alife workshops and conferences have been hosted in the US nine times（Los Alamos 1987,Santa Fe 1990&1992,MIT 1994,UCLA 1998,Reed 2000,Boston 2004, East Lansing 2012）,Japan once（Nara 1996）,Australia once（Sydney 2002）,England once（Southampton 2008）, and Denmark once（Odense 2010）. China's artificial life research has just started, set up a research organization, held a number of meetings, published nearly 200 papers, but the relevant research has caused by different domain experts, scholars, which is the great future of artificial life research in China.

Keywords: Artificial life; life; artificial intelligence; knowledge； knowledge progress

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INTRODUCTION

Artificial life（referred to as Alife or AL）definition has not been fully reached a consensus, but is generally accepted Renton's definition. He thinks, *Artificial life is such a research field:it attempts to extract contained in biological phenomena under the basic principle of dynamics to understand the life, and other physical media (such as a computer) to reproduce these phenomena, so that it will become a new experimental operation and test object*.[1]

Although the field of artificial life and artificial intelligence fields has significant overlap, but they have different intention and evolution. To study whether and how to realize the simulation of intelligent artificial intelligence research, early in the computer after the birth of initial stage has arisen, however in an attempt to reveal the natural behavior of artificial life researchers, lack of contact between each other, until the end of eighty's last century, researchers began to create groups, establish an organization, promote subject field form. [2]

The natural essence of life features mainly include: one is individual or individual differences. For different animal, different plants, in appearance, internal structure, behavior, physiological function, living habits, habitat, growth process and other aspects are all exactly the same. That is to say, the natural life personality traits such as *world no two same leaves*. The other is common. In the *personality* of *common*, namely the natural life have the functions and characteristics of mating breeding, genetic variation, the survival of the fittest self reproduction, evolution, self-optimization. The natural life have the process and performance of growing, the new supersedes the old. The natural life has a stable internal state, to adapt to the external environment, the dynamic balance of the self stable, adaptive, since the coordinated function and characteristics, in order to proteins and carbohydrates as the material foundation, gene control and domination. [3]

Natural life is perfect. The so-called artificial life can't be perfect, which are partially have natural life's

characteristics or traits. Usually those programs or systems which have the most natural life essence (usually require in addition to having the characteristics of biological organisms) known as artificial life. Therefore, so-called artificial life such as a computer program or the network language system as the carrier of the may not fully equivalent to the natural life. In addition, artificial life is not only the natural features of life and the phenomenon of artificial model, simulation system, the natural genetic offspring, replicating variant function, but also can extend the functions and characteristics of natural life, and has the improved varieties and evolution of function similar to natural life. [3]

2. Review of Foreign International Conference Of Artificial Life Research

Since Renton put forward "artificial life" in 1987, artificial life research has gone through more than 20 years. Now, The independent research status or subject about "artificial life" have been the international academic recognition. International journals *Artificial Life* which launched in 1994 and published by Mit publishing is authoritative publications in this field. Resources of artificial life is very rich in network. Artificial life's online garden *Zooland* had been reported specially by *Science*. [4]So far, the artificial life academia hosted international academic conferences 10 times.

2.1 Artificial Life □

The world's first artificial life conference was held in Ross Aladdin Moss ,New Mexico,the United States on September 1987,which is known as artificial life I (AL I). The collection of this meeting included 24 papers, mainly distributed in 5 aspects :*artificial life research theory, the phenomenon of life simulation, cellular automata, genetic algorithm, evolutionary simulation*. Renton delivered a pioneering thesis entitled *Artificial Life*, he proposed in the article artificial life concept, and discusses it as an emerging research field or discipline of the meaning of existence. Renton is recognized as the founder of artificial life research. The meeting marked the birth of artificial life research field. [5]

2.2 Artificial Life □

The world second times of artificial life conference was held in Santa Fe, New Mexico,American on February 1990,which is known as artificial life II (AL II). The conference's collection included 31 papers, the content have 8 parts Of divided into general, self-organization, evolutionary dynamics, development, learning and evolution, computation, philosophy and emergence, the future. Renton's *the edge of chaos of life* and John Koza's *genetic evolution and computer program coevolution* belong to the classic. [6]

2.3 Artificial Life □

The world third times of artificial life conference was held in Santa Fe, New Mexico ,the United States on June 1992, which is known as artificial life III (AL III). The of this meeting included 26 papers. The content involved genetic algorithm simulation, evolution, behaviour, fitness profiles, group dynamics and chaotic mechanism and artificial life classic content, also discussed the application problems of robot planning. Corzine's "artificial life: self replicate spontaneous emergence and evolution of the self improvement of computer program" from the genetic programming algorithm discussed in artificial life research of the key mechanism of emergence. [7]

2.4 Artificial Life IV

This meeting was held at Massachusetts Institute of Technology in the United States on July 1994, which is known as artificial life IV (AL IV). The papers collection of this meeting included 56 papers. The contents are divided into 3 parts about special report, long and short. It covered the collaborative evolution, genetic operator, evolution and comprehensive of other methods (such as neural network), AL algorithm, on the edge of chaos and bifurcation, AL modeling, learning ability, evolutionary dynamics, cellular automata, DNA disequilibrium theory research, the artificial life in character recognition, robotics and other aspects of the application of relatively wide content.[8]

2.5 Artificial Life □

This meeting was held in the ancient city Nara Japan on May 1996, which is known as artificial life V (AL V). More than 500scholars from all over the world attended this meeting. This is the first time that the artificial life meeting held in Asia. At the beginning of artificial life proposed, scholars in Japan have big attention .In the first international conference of artificial life Japanese scholars attended. This meeting was held in Japan, which is a sign of Japan to become Asia's artificial life research center.[9]

2.6 Artificial Life VI

This meeting was held at University of California in the United States on June1998, which is known as artificial life VI (AL VI). The theme of this conference is *life and Computation: changing boundaries*. The conference received approximately 100 of submitted papers, 39 of them as full papers in this conference papers concentrate are introduced. 9 papers are considered artificial life's new high quality work. This conference is main the paper relates

to the calculation of molecular and cell biology. The conference provided many new about the developmental process, cell differentiation mechanism and immune response model of manufacturing's new insights. [10]

2.7 Artificial Life VII

This meeting was held at the United States Portland Reed college on August 2000. The theme of the conference is *review the past, look to the future*. Specific issues discussed include the following aspects: the origin of life, self organization and self replication problems, including artificial chemical evolution, the catalytic system, the virtual new supersedes the old and so on; development and differentiation, including artificial and natural morphogenesis, cell differentiation and biological evolution, gene regulatory network and so on; evolutionary and adaptive dynamics problem, including artificial evolutionary ecology, evolution and its influence on biological tissue, evolutionary computation and so on; robot and intelligent agents, including evolutionary robotics, autonomous adaptive robotics and software intelligence body; communication, collaboration and collective behavior, including the emergence of collective behavior, communication and the evolution of cooperation, the language system, social system, economic system and socio technical system and so on; artificial life techniques and the application of the methods, including industrial and commercial applications, evolvable hardware, self repair hardware and molecular computing, finance and economics, computer games, medical applications, educational application and so on; epistemology and methodology, including artificial life ontology, epistemology, the ethical and social impact and so on. [11]

2.8 Artificial Life VIII

This meeting was held in Sydney on December 2002. The main discussions: the origin of life, self organization and self replication; differentiation and development; evolution and adaptation kinetics; robotics and autonomous Agents problem; communication, collaboration and collective behavior; artificial life techniques and the application of the methods, artificial life simulation and synthesis tools and methodology. [12]

2.9 Artificial Life IX

This meeting was held in Boston the United States on June 2004. The main content is robot show. Wolfram was invited to make a speech "a new science and artificial life in the future". [13]

2.10 Artificial Life X

This meeting was held at Bloomington in the United States on June 2006. The main content is a celebration of the 20 anniversary, as well as the development of cognition and expression, computational biology, complex systems and networks, some achievements of open problems. [14]

2.11 Artificial Life □

In 2008 The Eleventh International Conference on artificial life (artificial life XI) was held in the British city of Winchester the University of Southampton on June 2008. This is the first time that the international conference on artificial life was held in Europe. This is also the first time the conference papers were pubished by the MIT University Press online publishing, and were free for Congress and the public to display the meeting results and submit papers. The conference received a total of more than 250 delegates submitted 275 articles (including 145 full papers and130 abstracts). 95papers and 85 abstracts were selected to speak at the conference. This time also held a series of sister conference, such as the European Conference on artificial life. An important feature of this conference is making a large number of different domain experts, scholars into the field of research, broght the physicists, chemists, biologists, computer scientists, engineers, economists, geographers, linguists, psychologists, anthropologists, philosophers, mathematicians, musicians and artists to come together, to exchange ideas and inspiration. It also makes this the conference become an important meeting, and even the logo of the International Conference on artificial life.[15]

2.12 Artificial Life □

The Twelfth Meeting was held at University of Southern Denmark in Odense Denmark on August 2010. This meeting theme is *artificial life simulation* and *synthesis*, the conference logo is *the synthesis and Simulation of biological systems international conference*. The conference papers presented more concentrated in how to in the actual scene to survive, to obtain a positive development; for natural life simulation, synthesis and production, survival environment analysis problem again to be further strengthened; this also makes more in the field of science into the field . This meeting deep the consolidation of this concept: Conference on artificial life like a big tent, different scientists, experts, scholars came to rest, to exchange, there is no threshold, no limits, no review, as long as you are interested in artificial life, you can come here.[16]

This conference get 200 papers.156 of them passed to be accepted for the conference papers by peer. Authors come from 34 countries.4 papers were selected as the keynote speeches, and other papers made 15minutes group speech and5 minutes to discuss, this conference is a dynamic conference. keynote speeches and group speech are very

successful.[17]

2.13 Artificial Life 13

The Proceedings of Artificial Life 13 is the Thirteenth International Conference on the Simulation and Synthesis of Living Systems, hosted by the BEACON Center for the Study of Evolution in Actionat Michigan State University in East Lansing, Michigan, on July 19-22, 2012. This year's conference was organized into five submission tracks: Evolution in Action, Behavior and Intelligence, Collective Dynamics, Synthetic Biology, and the Humanities and ALife.[18]

2.14 Other foreign Conference on artificial life

In addition to the 13 international artificial Life conference, regional international conferences were gradually organization. For example,"*European Conference on Artificial Life*（referred to as ECAL）"also have been held for 5 sessions, each session has a collection of papers published. ECAL has become an important forum about international research of artificial life .

3. Overview Research on Chinese Artificial Life From CNKI

In CNKI (http://www.cnki.net) literatures, literatures of *artificial life* have 79 (time up to 2012-12-20), these literatures roughly as follows 3.1 to 3.9.[19]

3.1 The number of papers published in different years

According to the quantity of published papers sort is：

year	2005	2007	2003	2004	2006	2009	2011	2002	2008
number	22	20	19	15	14	13	12	12	11

year	2010	2001	1998	2000	1994	2012	1999	1997	1995
number	8	6	6	5	4	4	3	2	2

3.2 The number of papers published in different source database

According to the quantity of published papers sort is:

source database	number
China Academic Journal Network Publishing Database	130
Chinese Master Dissertations Full-text Database	22
Chinese important conference papers database	16
Chinese Doctoral Dissertations Full-text Database	4
the national science and technology achievements database	4
China Core Newspaper Database	1
China Patent Database	1
international conference papers database	1

3.3 The number of papers published in different Research project's funding

According to the quantity of published papers sort is:

Research project's funding	number
National Natural Science Foundation of China	42
National Laboratory of pattern recognition (Institute of Automation CAS) open projects fund	3
National high technology research and development program of China (863 Program)	2
higher doctoral scientific research fund	2
Chongqing Municipal Science and Technology Commission Fund	2
State Key Laboratory of intelligent technology and systems (Tsinghua University) Open Research Fund	2
Natural science foundation of Shandong province	2
Beijing City Board of Education Science and Technology Development Fund	1
and so on	……

3.4 The number of papers published in different Literature published sources

According to the quantity of published papers sort is:

Literature published sources	number
Computer Engineering and Applications	8
Pattern recognition and artificial intelligence	7
Computer simulation	6
Study in Dialectics of nature	6
Northeast Normal University	5
Journal of system simulation	5
Chongqing University	5
Journal of Nanjing Forestry University (social sciences edition)	3
Computer engineering and design	3
Computer application	3
Jilin University	3
Science and Technology	3
Popular science news	3
Complex systems and Complexity Science	3
Computer application research	2
and so on	……

3.5 The number of papers published in different Author's work unit

According to the quantity of published papers sort is:

Author's work unit	number
University of Science and Technology Beijing	19
Chongqing University	11
Northeast Normal University	7
Jilin University	6
Institute of Automation Chinese Academy of Sciences	6
Tongji University	6
Guangxi University	6
Zhejiang University	5
Beijing Normal University	5
Qingdao University	4
Beijing Institute of Technology	4
Southwest University of Science and Technology	4
University of Science & Technology China	4
PLA University of Science and Technology	4
Chongqing Institute of Technology	4
Chongqing University of Technology	
Donghua University(3), Nankai University	
Chinese Academy of Sciences Institute of computing technology	
and so on	……

3.6 The number of papers published in different Literature author

According to the quantity of published papers sort is:

Author's name	Author's work unit	number
Xuyan Tu	University of Science and Technology Beijing	14
Xiaojuan Ban	University of Science and Technology Beijing	9
Yixin Yin	University of Science and Technology Beijing	5
Rui Gao	Guangxi University	5
Zushu Li	Chongqing University	4
Hongjuan Chen	University of Science and Technology Beijing	4
Guofeng Zhang	Chongqing University	4
Yonghua Zhou	Guangxi University	4
Guowei Yang	Qingdao University	4
Jianhui Li	Beijing Normal University	4
Xiaolin Quan	Northeast Normal University	3
Jianmin He	PLA University of Science and Technology	3
Qian Xu	Northeast Normal University	3
Huang Wen	Zhejiang University	3
Yousong Chen	Beijing Institute of Technology	3
Yuanyuan Wang	PLA University of Science and Technology	3
Ren Xiaoming	Nankai University	3
Zushu Li	Chongqing Institute of Technology	3
Han Liqun	Beijing Technology and Business University	
and so on	……	……

3.7 The number of papers published in different Subject category

According to the quantity of published papers sort is:

Subject category	number
automation technology	94
computer software and computer application	43
biology	18
Philosophy	8
natural science theory and method	6
computer hardware technology	3
Biomedical Engineering	3
arms industry and military technology	2
nonlinear science and Systems Science	2
the art of calligraphy sculpture and photography	2
psychology	1
ethics	1
industrial generic technology and equipment	1
Internet technology	1
telecommunications technology	1
environmental science and resource use	1
light industry	1
handicraft industry mining engineering	1
clinical medicine	1
highway and waterway transport	1
sociology and Statistics	1
business	1
macroscopical economy management and sustainable development	1
and so on	……

3.8 The number of papers published in different Chinese key words

According to the quantity of published papers sort is:

Chinese key words	Frequency of use
artificial life	125
artificial intelligence	16
genetic algorithm	14
evolution	12
the complex system	9
emergent	8
behavior choice	8
a cellular automaton	7
cellular automata	6
generalized artificial life	6
digital life	5
emergent cluster	5
artificial life algorithm	5
artificial tissue	4
complexity	4
simulation	4
multi-agent system	4
the virtual biology	4
combat simulation	4
emerge in large numbers	4
emotional	3
image segmentation	3
Life Sciences	3
computer animation	3
artificial society	3
life behavior	3
evolutionary computation	3
virtual reality	3
L system	4
behavior characteristic function	2
artificial life algorithm (ALA)	2
war system	2
Agent modeling and simulation	2
current behavior	2
integrated simulation method	2
virtual fish	2
swarm intelligence	2

hiding behavior	2
key frame	2
artificial fish	2
the complex adaptive system	2
animation engine	2
analog	2
embedded systems	2
intelligent control	2
strong artificial life	2
sensory-motor intelligent schema	2
the philosophy of artificial life	2
behavior selection model	2
artificial life system	2
artificial life and natural life	2
behavior simulation	2
self-reproduction	2
virtual plant	2
Agent	2
image processing	2
functional	1
and so on	……

3.9 Cited more than 10 times literature

Cited more than 10 times literature include: [1] SWARM-a support artificial life modeling object oriented simulation platform. Hao Ding, Xiaoping Yang. Journal of system simulation,2002-05,95; [2[from artificial life to artificial societies -- complex social system current situation and prospects of research on Feiyue Wang,Steve Rankin Sen. complex systems and complexity science,2004-01,66; [3[the cellular automata and artificial life research progress. Guang-Wu Yan. Journal of Jilin University (science edition),2003-03,37; [4[artificial life: exploring new forms of life. Jianhui Lee. Journal of Dialectics of nature,2001-07,31time; [5] "artificial life "research progress. Yongguang Zhang. Bulletin of the Chinese Academy of Sciences,2000-05,26; [6] research of artificial life for computer animation-the self-reproduction model of artificial fish. Hongjuan Chen, Xiao-juan ban, Xuyan Tu, Hanqing Lu. Journal of automation,2003-11,18; [7] review of artificial life research. Haifei Yu, Dingwei Wang. Information and control,2004-08,16; [8] artificial life. Dengyong Zhou, Ruwei Dai. Pattern recognition and artificial intelligence,1998-12,16; [9] the trees growing computer imitation Really-a problem of the artificial life. Sheng Xu, Zhendong Yuan. Journal of Southeast University [natural science edition],2003-12,15; [10] development and Research on artificial life. Jianmin He, Yuanyuan Wang. Journal of PLA University of Science and Technology (natural science edition),2003-07,15; [11] artificial life simulation analysis. Pei Jiang, Hongyan Wang, Jingan Yang. Changsha Railway University,1999-06,15; [12] overview of artificial life. Diming Ai, Hongjuan Chen, Xiao-juan ban, Xuyan Tu. Computer engineering and applications,2002-01,15; [13] virtual cells-artificial life model. Yongdong Sun, Jian Tang, Tong Shang, Mingsheng Zhao. Chinese medicine Magazine,2001-11,14; [14] artificial life concept, content and method. Hongjuan Chen, Xiaojuan Ban, Diming Ai, Xuyan Tu, Hanqing Lu. Journal of University of Science and Technology Beijing,2002-06,14; [15] the computer artificial life. Ruian Hu, Jiyang Hu, Shu Xu. Science and technology review, 1994-12, 14; [16] based on genetic algorithm demonstration system design. Xiaoping Wang, liming Cao, Hongbao Shi. Journal of Tongji University [natural science edition],2003-02,12; [17] the artificial life Life studies. Bin Wu. Journal of Southwest University of Science and Technology (natural science edition),2002-09,12; [18] from the complex system from the perspective of the theory of artificial life development. Xiaoming Ren, Baohua Luo. Studies on Dialectics of nature,2003-04,10; [19] life based combat simulation model study. Jianmin He, Yuanyuan Wang. The computer simulation,2004-06,10; [20] the artificial life method of computer animation –" artificial fish" modeling and generating. Xiaoyuan Tu, Hongjuan Chen, Xuyan Tu. The world of software,2000-04,10.

4. Books published in China and the academic conference held in China

In China there have been more than 10 published monographs related to artificial life. For example, *Artificial intelligence and artificial life* (Shaozhong Cao, Xuyan Tu, publishing house of electronics industry,2011), *The complexity of artificial life research methods* (Huifeng Xue, National Defense Industry Press,2007),*Artificial life* (Guowei Yang, Science Press,2005), *Generalized Artificial life* (Xuyan Tu, Liqun Han, Hongbo Wang, Science Press,2011), *Digital Genesis: the new science of artificial life* (Jianhui Li, Jiang Zhang, Science Press,2006), *Wireless sensor network and artificial life* (Xiao-juan Ban, National Defense Industry Press,2008), *Toward the computationalism: digital age to create artificial life philosophy* (Jianhui Li, China Books Press,2004), *The secret life of machines* (Xiaogang Ruan, Beijing University of Posts and Telecommunications press,2005), *The secret life of machines* (Xiaogang Ruan, Beijing University of Posts and Telecommunications press,2005), *Artificial fish* (Xiao-juan Ban, Science Press,2007), *Synthetic biology* (Kai Song, Science Press,2010.), *" software" research and application* (Guangping Ceng, Xuyan Tu, Hongbo wing, Science Press,2007),and so on.

Generally speaking, Chinese scholars in contact with artificial life research field is late, the artificial life research is still in its initial stage of development. Until August 1997, the first domestic *Artificial life and evolutionary robots* seminar is jointly organized by the Chinese Academy of Sciences Institute of systems science, Institute of automation and Huazhong University of science and technology of pattern recognition and Artificial Intelligence Research Institute in Beijing. The activity invited 10 experts made 15 special subject lectures, and discussed *artificial life and complexity* and *robot* two special subject study. It is important for more Chinese scholars to pay attention, understand and add to the artificial life research field. This seminar became the official start of the artificial life research. In October 2002, the first artificial life and Its Applications academic conference was held in Beijing organized by the Chinese Association for artificial intelligence. In July 2004, Sino-Japanese artificial life conference was held in University of Science and Technology Beijing. In September 2005, Chinese Association for artificial intelligence held second workshop on artificial life. [20]In November 2010, the *philosophical thinking of artificial life techniques* seminar was held in Tongji University. In October 2011 *Chinese Conference of artificial life and intelligent robot* was held in Hefei University of Science and Technology of China. In addition there are some artificial life research organizations, such as *Chinese Association for artificial intelligence in bioinformatics and artificial life professional committee*,and so on.

CONCLUSION

Artificial life is an emerging interdisciplinary science. The research fields include computer science, biology, automatic control, system science, robotics, physics, chemistry, economics, philosophy and other disciplines. The object of Artificial life research is the natural features of life and life phenomena of artificial system or computer programming language system. Research is focused on the artificial system model generation method, key algorithm and Realization technology. [21]

The current international on generalized artificial life research mainly involve the two major areas: engineering technology and biological engineering. The specific research contents include cellular automata, digital life, digital society, digital environment, artificial brain, evolutionary robotics, virtual biology, evolutionary algorithm, cloning technology, transgenic technology and so on several aspects. Usually, *Artificial Life* mainly refers to the digital world to create a virtual version of the artificial life and in the real world to create a robot version of the artificial life. [22]

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REFERENCES

[1] Jianmin He, Yuanyuan Wang. *Journal of PLA University of Science and Technology (natural science edition)*, **2003**; (3):11-16.
[2] Xijing Zhang. *Citrus trunks structure visualization modeling and multi granularity present*. Northeast Normal University,**2009**.
[3] Diming Ai, Hongjuan Chen, Xiaojuan Ban, Xuyan Tu. *Computer engineering and applications*, **2002**;21(1):1-4.
[4] Jianhui Lee. *Natural dialectics research*, **2001**;20(7):1-5.
[5] Hong Ma. Based on animat model intelligent optimization model. *Shandong University*,**2006**;pp:52-56.
[6] Wen-Bing Gong, Yin-Bing Bian, Rui Xu and Yang Xiao. *Journal of Pure and Applied Microbiology*,**2013**;7(4): 863-869.
[7] Bin Wu. *Artificial life research*. Journal of Southwest University of Science and Technology (natural science edition), **2002**;78(3):60-65.
[8] Arghavan Chaibakhsh1, Khosro Issazadeh, Sara Kazemi Rad and Mahnaz Farahmand. *Journal of Pure and Applied Microbiology*,**2013**;7(4): 1145-1149 .
[9] S. Melvin Samuel, Visenuo Aiko, Pragyanshree Panda and Alka Mehta. *Journal of Pure and Applied Microbiology*,**2013**;7(4): 965-971 .
[10] Rashed Noor, Zahidul Islam, Saurab Kishore Munshi and Farjana Rahman. *Journal of Pure and Applied Microbiology*,**2013**;7(4): 899-904.
[11] Sibanda Timothy and Okoh I. *Journal of Pure and Applied Microbiology*,**2013**;7(4): 1189-1206.
[12-22]Xinhua Lu, Jigui Sun, Xiaosong Han, Rong Xing. *Artificial life: computer and Biology Intersect discipline*. In computer science,**2008**; (5):9-13.
[15] *Artificial Life XI* .http://www.mitpressjournals.org/loi/artl.
[16][17] *Artificial Life XII*. http://www.mitpressjournals.org/loi/artl.
[18] *Artificial Life 13*. http://www.mitpressjournals.org/loi/artl.

[19]Liu Yang, Liwei Tian, Kuyuan Hu, Yunlong Zhu. *Journal of Pure and Applied Microbiology*,**2013**;7(4): 1299-1305.