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웹기반 이러닝 멀티에이전트 시스템

An Intelligent Web based e-Learning Multi Agent System

조영임
Young Im Cho

* 수원대학교 컴퓨터학과

Abstract

In this paper, we developed an intelligent web based e-learning system based on multi agents. To do development of the system, we applied an inclination test that is based on the education theory to do grouping the desirable e-learning community. The proposed system, Intelligent Web based e-learning Multi Agent System (IMAS), is used the multi agents paradigm including learning manner by neural network for grouping of e-learning community and a new distributed multi agent framework proposed here.

Key Words : e-learning system, multi agent, on-line community

요 약

이 논문에서는 멀티에이전트 기반 지능형 웹기반 이러닝 시스템을 구현하였다. 이 시스템 구현을 위해 사용자들의 취향검사를 수행하였고, 결과 사용자 그룹에 맞는 적절한 이러닝 커뮤니티를 형성하였다. 제안하는 시스템인 IMAS는 신경회로망에 의해 이러닝 커뮤니티를 학습하였고, 새로운 분산기반 멀티에이전트 프레임워크를 이용하여 에이전트를 생성한다.

Key Words : 이러닝 시스템, 멀티에이전트, 온라인 커뮤니티

1. 서 론

In an information society, the capability of a learner to accomplish goals through collaborating as a member of a society isas important as the capability to simply acquire knowledge. This capability is not acquired through repetitive learning, but consists of acquiring real knowledge that can be used in society to adapt oneself to social change. Therefore, an educational system has become necessary not only to learn fragmentary knowledge but also to develop the capability to accomplish learning tasks through collaborative learning with other members of the society.

As many researches have shown, the dropout rate in e-learning is higher than that in traditional face-to- face learning due to its low degree of continuity. In order to lower this dropout rate, many researches have been done to heighten the degree of learners' satisfaction and to provide them with motivation [1,2].

The agent system, which began to appear in the 1990s, is a system that is automatically managed and self-operative. It is a very intelligent concept that can manage the information of each learner in the e-learning system, and recommend and search information that fits the inclination of each individual [3]. By applying the concept of the agent to the e-learning system, we can develop the next generation's technology which will contribute to the increase of the degree of satisfaction of learners, as well as the degree of learning achievement, by analyzing the inclination of each individual learner and reflecting its result in each group.

In this paper, as we recognize the importance of a learning community and intend to form a learning community which is strong and at the same time, the most feasible, we will develop an intelligent web based e-learning multi agent system through the questionnaire called the inclination test with the method of intelligence based agent which will reflect the inclination and characteristic of an individual learner.

This paper is consisted of the followings. Chapter 2 will explain the online learning community, motivation theory and agent theory. Chapter 3 will explain the system overview, module specification and the algorithm of the proposed system. Chapter 4 will evaluate the proposed system. And finally a conclusion is in chapter 5.

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2. Online Community on the e-Learning

The background of the formation of online learning community is as follows [4,5,6]. First, a learning community is said to start from a social-constructivism which emphasizes a social context. A true learning starts and develops more in the collaborative learning environment in which diverse learning resources and opinions

are provided, rather than in an individual task accomplishment by a learner. Therefore, a learning community is a form of learning to which a constructivism is applied, in that it provides its members with social context in which they share the common interest and interact with one another dynamically. Secondly, a learning community starts from the viewpoint of learning how to learn. that is, a learning community emphasizes a learner-centered constructivism which improves the capability of a learner to solve real-life problems by processing diverse information scattered around a learner. Third, the meaning of a learning community is emphasized in confrontation with cultural diversity. The learning opportunities and environment should be provided to a learner so that the learner can construct a unique perspective on its own through dynamic interaction with diverse learners of a learning community to which an individual learner belongs. Fourth, with the rapid development of technology, the formation of a learning community that transcends time and space is becoming a reality. That means the advent of online learning community equipped with infinite possibilities.

To secure the trust in electronic space characterized by its lack of face-to-face quality and anonymity is an important issue that must be solved for the formation of electronic communities in which individual identity and trust will be constituted [7,8]. The online learning community is a relative term to offline learning community or traditional learning community. In order to form a desirable cyber learning community, one should understand first of, all what influences a cyber community.

Generally, the dropout rate of e-learning is higher than that of traditional face-to-face learning by 10 to 20 %. The reason is that it puts more emphasis on grades than on learning, and also that the participants are physically apart from one another. Therefore, in order to lower dropout rates and increase learning effects, a social environment should be continuously provided to the learners, and they should be induced to participate in learning activities through provision of a strong sense of [9].

3. Intelligent Web based e-Learning Multi Agent System

3.1 IMAS Overview

On the basis of the above researches, firstly we present a list of homogeneity and heterogeneous items for inclination testing for the effectiveness of online e-learning community.

As for a questionnaire, 10 items are included which are considered to be adequate for grouping, according to the characteristics of each category. First, among 6 items for homogeneous testing, the major category signifies a teacher's major, which are then classified into such sub-items as Korean language, mathematics, English, science, social studies, etc. Teachers in junior and senior high schools are supposed only to select the class which they are currently teaching. As for elementary school teachers, their own major should be selected. The teaching career category is classified into less than one year, one to five, six to ten, eleven to fifteen, sixteen to twenty and more than twenty years. As for favorite sports, they are classified into mountain climbing, workout, golf, tennis, swimming and others. The hobby categories are movie, Paduk, fishing, reading, web surfing, game and etc. And favorite food and favorite color are also classified into sub-items. But those learners who have similar inclination may show cultural diversity and have diverse opinions. So we have added diversity by selecting four items such as online training experience, residential area, gender and duration of computer use.

Second, the heterogeneous testing items are 4 items such as living region, gender, duration of computer use, and online training experience.

And then, to verify the effectiveness of the online e-learning community by inclination test items, we adopt the agent theory. The agent system is an independent area that has been studied in the field of artificial intelligence for a long period of time. It has been recognized as a separate field of research since the early 1990s. It signifies a system which percepts the environment through its own sensors and takes actions against that environments with its effectors [3,11]. The agent system is an autonomous process which solves tasks wanted by a user automatically, asa substitute for the user. It operates mainly in distributed environments. It is a software system with an independent function that can perform its own task by itself. Distributed Artificial Intelligence is a concept that first appeared near the end of the 1970s. Its researches are concentrated on the fusion of multi-agent systems and distributed problem-solving systems. In multi agent systems, each agent performs a job in part and the overall goal is achieved through interaction among agents. The most representative paradigm of such an interactive adjustment is the FA/C(Functionally Accurate Cooperative paradigm) [10].

In the area of e-learning, individual learning achievement should be regarded as an important goal. Therefore, the e-learning area is not a generalized, homogeneous system, but should be regarded as a field where individual learning achievement is reflected in a very sensitive manner. It is necessary to construct a personalized learning system on the basis of a strong learning community and the motivation theory as explained before.

Information from individual learners through security and certification procedure as seen in Figure 1 is inputted to the system, Intelligent Web based e-Learning Multi Agent System (IMAS), to be proposed in this paper, and IMAS creates each user's profile from the

information. Based on it, learning community grouping suitable to each individual is automatically executed by using Self Organizing Feature Map (SOM) learning algorithm via multi agents.

In IMAS, the grouping and the learning is automatically performed on real time by multi agents, regardless of the number of learners. A new framework has been proposed to generate multi agents, and it is a feature that efficient multi agents can be executed by proposing a new negotiation mode between multi agents.

Overall structure is composed of the user information (user, learner), user profile in which user's tendency is saved, e-learning database, which processes digitalized learning information and distributed multi agent framework (DIMAF), which generates multi agents, as well as multi agents that are comprised of grouping agent deciding a learner's group form DIMAF, user profile update agent who continuously updates learner's information continuously and learning evaluation agent who automatically informs learning evaluation as seen in Figure 1.

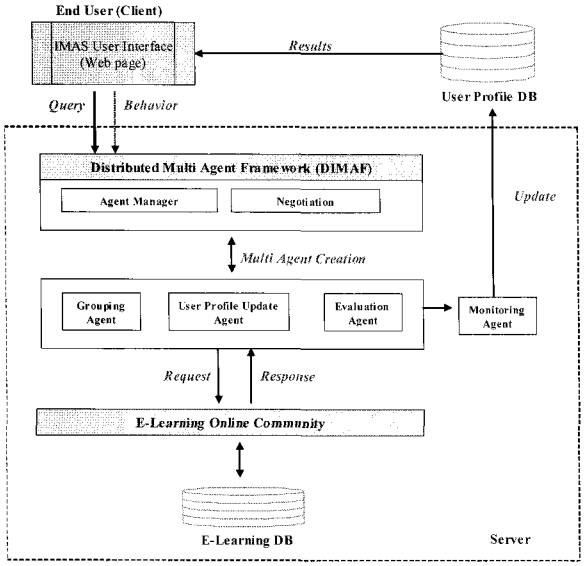


Figure 1. IMAS System Configuration

3.2 IMAS Main Functions

On of multi agents in IMAS, Grouping agent is generated by learner's drawing up a distribution map related to items using Kohonen's SOM learning algorithm, based on inputted information for homogeneity and heterogeneity. When homogeneous and heterogeneous items are inputted respectively, input vector is generated in order pairs, each. Then, learning grouping is automatically executed with the weight provided by drawing up a categorization map on real time through SOM network [11].

After generating user profile after real time grouping by using initial user input items, update the user profile when requests of a learner comes in additionally or when the learner's work information has been updated.

When an agent is generated, DIMAF consists of the negotiation algorithm between the agent name server (ANS) providing agent ID, an agent manager controlling and monitoring generation, execution and movement of agent and multi agents.

As you see in Figure 2, the negotiation algorithm is greatly required for suitable grouping from grouping list by searching learned user profile with user input item inputted at an early stage in the grouping agent. In the grouping list, the user (ID), group number (G), satisfaction degree (SD) and team information (TI) are recorded. TI is recorded as a value among maintenance (M), don't care (D) and break (B). Maintenance (M) is the case where satisfaction degree of previous group members is very high, which means the value is required to be maintained constantly, not desiring to break. Don't care (D) is the value meaning that it may be changed, according to learners' responses in the normal position. Break (B) means the group to be regrouped, after breaking existing group, since satisfaction degree of the previous group members is very low.

The detailed negotiation process by negotiation algorithm proposed in this paper is as follows:

- Step 1: Grouping agent searches concerned individual (ID), group number (G), satisfaction degree (SD) and team information (TI) from grouping list by inspecting user profile from the homogeneous items categorized primarily. If a concerned ID's TI value is M, the concerned grouping is maintained without executing 2nd step and you need to move to step 4. If TI value is D or B, you need to move to step 2 and continue.
- Step 2:From the table saved in the temporary storage, grouping agent (GA) calculates Gand SD which performed grouping by SOM learning algorithm by using user input homogeneous item. If TI value was B, you need to move to step 4, beyond step 3.
- Step 3: When the grouping result value performed by GA in step 2 and the G value of grouping list are different, concerned grouping should be maintained in the user ID with priority in the result of grouping list in the user profile.However, concerned user should judge by showing the group member list to concerned user (ID).
- Step 4: Show grouping information and member list to each learner.

Four multi agents are generated basically in the IMAS system. Grouping agent (GA) is the agent that generates user profile using 1st categorization criteria (homogeneous) and 2nd categorization criteria (heterogeneous). GA is in charge of grouping. User profile update agent (UA) is the agent that saves user history and helps grouping performance, while consulting GA.

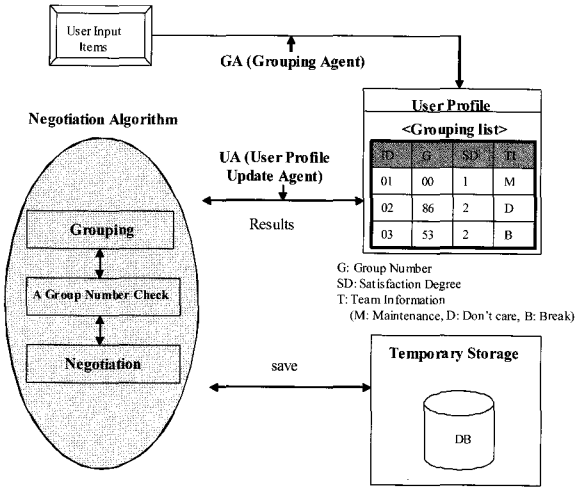


Figure 2. The functions of multi agents

Evaluation agent (EA) evaluates learning satisfaction degree of user and grouping members and decides whether to maintain, don't care or break this group, according to satisfaction degree value. In the PAGE system, a learner evaluates the group set by grouping with 5 patterns (very satisfy, satisfy, normal, unsatisfy, very unsatisfy). EA is the agent playing a role to provide a learner with guideline onto leave the concerned group, based on group evaluation data to which the learner belongs and his/her own input data. And, EA automatically moves the learner to a new group suitable and not exceeding prescribed number of the group, when the user decides to leave the former group. The presentation of guideline to break the concerned group from EA is made up by using error back propagation learning algorithm of neural

Monitoring agent (MA) is the agent to identify state of a learner (user) by monitoring the number of grouping, number per group and satisfaction degree per group graphically through monitoring of learners' learning status.

In IMAS, grouping forms group via grouping agent. The grouping agent indicates homogeneous and heterogeneous distribution from homogeneous and heterogeneous items selected by a user through the use of SOM algorithm. Automatic grouping is made by learner's input with this distribution.

Among homogeneous items as you seen in section 2, a user selects detailed items (i.e. major subject is Korean) regarding each item. In the IMAS, 6 input nodes and random 10*10(=100) output nodes are provided for a learner to learn using learning algorithm of the SOM network regarding each detailed input value of the user-input homogeneous value. Here, the reason why 100 output nodes are provided is because maximum number of cases in which homogeneity can be generated is limited to 100.

With regard to input value, values were randomly generated in order of major subject, favorite sports, etc, giving priority to each item by valuing homogeneous values numerically. For example, ID: yicho1234, major subject: Korean, teaching experience: 1-5 years, favorite sport: swimming, hobby: movie, favorite food: Chinese food, favorite color: yellow were selected, they are expressed in the following data structure order by with priorities in order.

Here, it is the result of learning of 10,000 people, which shows the concerned grouping distribution with regard to input node. When the distance of WIN by SOM, with regard to input vector I, is set as D_j , distribution range as B, B sets the range up to A by dividing Dj,which is the minimum WIN value, which is the distance (D_j) between input vector and connection weight via SOM by the number of random group number (C).Here, Max(D_j) and Min(D_j) mean maximum and minimum value of Dj respectively.

Homogeneous group's categorization map is formed by the above formula regarding input node. In this case, group number C was categorized as 100. A user with ID 1 was categorized into group 2.

Among four heterogeneous items inputted by a user, nodes with regard to four detailed input values selected by the user and random 6*6(=36) output nodes are provided, and the user learned in the SOM network. Here, the reason why 36 nodes were provided is because maximum number of cases where heterogeneity can be generated was limited to 36.With regard to input values, they have been generated randomly with a priority in order of area and gender based on the priority of each item by valuation of heterogeneous values. The input values regarding four detailed items were generated randomly by valuing heterogeneous values numerically. Like homogeneity, each detailed item selected with regard to four items was valued numerically and then learned.

For example, if ID: yicho1234, area: Seoul/Kyeonggi-do, gender: female, computer using hours: 1-2 hours, online training experience: yes were selected, the data structure of input node of the concerned ID is as follows. Like homogeneity, Figure 6is the figure that indicated WIN, the minimum distance value by input value via SOM. The circle indicates the distance value of concerned WIN. Here, users can learn through 10,000 inputs in the input nodes. Like homogeneity, output group distribution is formed in relation to input node. In this case, the number of group was 16. A user with ID 1 was categorized into heterogeneous group 4 in this instance.

Group is generated through input of learners with the distribution generated by homogeneous and heterogeneous SOM learning. The number of total group is decided by the number of people in a group, which is performed by manager's input. The input items of a learner are made by selecting 10 input items (homogeneous, heterogeneous). In order to meet homogeneity and heterogeneity with homogeneous and heterogeneous distributions learned through 10 input vectors, final learner's group meeting homogeneity and heterogeneity is

generated by providing weight to each vector. The size of learning group (size of community) can be designated by manager randomly.

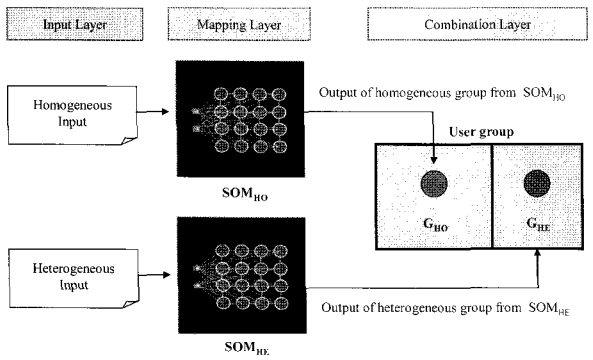


Figure 3. Final grouping process

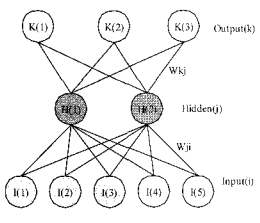
Finally, the homogeneous categorization map generates the final group for learning by randomly taking among groups excluding m to which concerned learner ID belongs in Figure 3.

4. Performance

The IMAS system developed in this paper has configured the Web server using Linux server, and database has been built using Mysql. Web program was comprised using ASP and PHP, and the agent's source code was configured with Java using DIMAF framework.

4.1 User Agent

User satisfaction degree is performed by evaluation agent. User (learner) satisfaction degree has 5 input values and the user satisfaction degree is evaluated in three such patterns as maintenance (M), don't care (D) and break (B) through error back propagation (EBP) learning algorithm. EBP is comprised of three layers (input layer, middle layer and output layer), and the learning is performed by changing connection weight through generalized delta rules. Learning through teacher is carried out by receiving the output layer data as input data with regard to input layer data. The input layer indicates satisfaction degree of users as values.



Input					Output		
VS	S	N	US	VUS	M	D	B
5	0	0	0	0	1	0	0
0	5	0	0	0	1	0	0
0	0	5	0	0	0	1	0
0	0	0	5	0	0	0	1
0	0	0	0	5	0	0	1
4	1	0	0	0	1	0	0
...	...	...	...	...	...	...	...
1	1	1	2	0	0	1	0
1	1	1	1	1	0	1	0

VS: Very Satisfy / S: Satisfy / N: Normal / NS: Unsatisfy / VNS: Very Unsatisfy

Figure 4. Neural network structure for user satisfaction degree

In IMAS, evaluation agent set the input nodes of input layer to be 5, and output nodes to be 3 indicating user satisfaction degree, and the middle layer's nodes were two as seen in Figure 4.

The 5 indicating very satisfactory in Figure 9is the value indicating member's satisfaction degree of group as value. After finishing learning, the status of maintenance, don't care and break is judged by inputting after regularizing to 5, regardless of the number of learners per group. The same principle applies to the remaining values, as well.

A neural network such as EBP has connection weight (W) in each layer, and the data inputted into input layer (learning data: input) is delivered to middle layer in a forward direction, and provides result value in the output layer. Perform learning, while adjusting connecting weight (W) in the direction of reducing difference by comparing the result value and expected data value (learning data: output), and by controlling connection weight (W) of own layer in the lower layer, based on back propagation in the upper layer. The status of incurred value from this stage (maintenance, don't care, break) is updated by each user via the user profile update agent, and the information is maintained and reported to each user.

Through homogenous and heterogeneous categorization maps, a total of 151 groups, which reflected homogeneity and heterogeneity by the number of learners per group (size of learning community, In this paper, it is 10), were generated via homogenous and heterogeneous categorization maps as well as via result to be grouped in the IMAS in consideration of number of learners per group (size of community). The reason why 151 groups were generated, despite members were 1,000, is because they are comprised of only members within homogenous categorization map (user with the same homogeneity). In this way, groups reflected homogeneity and heterogeneity were formed.

Generally, the size of community greatly impacted learning activities under the environment with computer as intermediation. The reason is because interaction is little, if the size is too small, while it is likely to be overwhelmed, if the size is too large. It is difficult to talk about adequate community size, since it differs according to curricular content, teachers or learners, but people from 8-9 to 20-30 are said to be adequate. For example, there are 39 members in homogeneous groups, G00, and number of people per group is 10, a total of four final learning groups (g1, g2, g3, g4) are generated reflecting heterogeneity, and the number of members of g1, g2 and g3 are 10, and that of g4 will be 9.

In this paper, a pilot test was conducted to evaluate actual users of the IMAS system If the scale indicates 1 in satisfaction degree, it means very satisfactory, if the scale is 5, then it means very unsatisfactory. The scale from 1 to 5 with regard to 5 categories was expressed as value. Here, satisfactory means that members of a

group or learning desire show a very positive result.

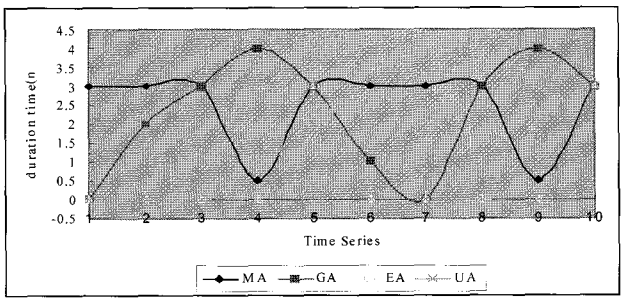


Figure 5. The average duration time and cycle in IMAS

As a result of surveying users' group satisfaction degree regarding 151 groups in the above Figure 9, we can see the average was distributed around scale value 2 of satisfaction degree. Accordingly, when automatic grouping was performed by agent, learners were generally satisfied. When they desired to maintain their group according to the value 2, around 51 groups of total 151 groups (34%) showed in favor of maintenance, while 61% showed don't care and less than 5% showed break.

When calculating average of the ratios of 6 items in the homogeneous group. When considering only homogenous group items, major subject (68%), teacher's experience (15%), favorite sports (9%), hobbies (4%), favorite food (35%) and favorite color (15%) were distributed in order. Namely, major subject and teacher's experience can be important factors to decide the homogenous group.

The agent's duration (or activation) time by DIMAF framework on time slice in IMAS is drawn in Figure 5. In Figure 5, after GAis activated, UA is activated. But MA is activated all the way except the activation time of GA. EA is activated after GA's activation. This cycle is repeated in IMAS e-learning system. Owing to DIMAF, IMAS can activate intelligently among many users in ubiquitous environment.

The distribution of heterogeneous items (area, gender, computer using hours, online training experience) in relation to 449 users of 51 homogeneous groups, which desire strong maintenance The criteria evaluating group satisfaction degree of learners have been indicated in order of online training experience, computer using hours, gender and area. Accordingly, when learners are grouped in a group with greater online training experience or computer using hours, the learners' satisfaction degree became greatly higher; and thus it was discovered that they desired to maintain the group continuously.

5. Conclusion

To do development of e-learning community system, we have made an inclination test questionnaire for the formation of effective and efficient online learning community. And then, we have implemented and realized an automatic grouping system with information of learners that appear through the questionnaire and by using an intelligent agent.

The results of our experiment with 1,000 people in reality by means of developing the grouping system have shown that 151 groups are automatically formed. Among them, 34% have shown very high degree of learning satisfaction and intended to maintain the groups in the future. In terms of homogenization, teachers who share the same majors and have longer teaching career have formed a group with a higher degree of homogenization. As for diversification grouping, online training experience and longer computer use have resulted in the increase of the degree of learning satisfaction.

In this paper, with the results of the inclination test designed to form a desirable online learning community, and through grouping systems that utilize the intelligent agent system, we have found out the possibility of lessening the feeling of isolation and lowering dropout rates that may frequently occur in online learning. As for the degree of satisfaction concerning the grouping system, within the category of hobby, the group of those who selected fishing as their favorite hobby has shown a higher degree of satisfaction (45%) than other groups. The importance of grouping is revealed through the inclination test. When group members are satisfied, dropout rate stemming from feeling of isolation will decrease and thus maintenance and continuity motivations can be maintained.

In the future, it is necessary to improve services concerning the communication between by supplementing the grouping system and to continue research on which multi agent system can be achieved effectively in automatic grouping.

Reference

[1] M. J. Rosenberg ,E-learning: Strategies for Delivering Knowledge in the Digital Age, McGraw Hill, New York, pp.28-29, 2001.

[2] A. P. Rovai,"Building sense of community at a distance". International Review of Research in Open and Distance Learning, vol.3, no.1, 2002.

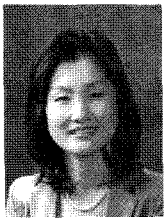
[3] Stuart Russel, Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall International Editions, 1995.

[4] K. Bielaczyc, and A. Collins, Learning communities in classrooms: Are conceptualization of educational practice. In C. M. Reigeluth (Eds.) Instructional -design theories and models Lawrence Erlbaum Associates, NJ pp.269-292, 1999.

[5] B. Winson, and M. Ryder, Dynamic learning communities: An alternative to designed instructional system. [online] available

htt://carbon.cudener.edu/~mryder, 2001.
[6] B.Winson, M. Ryder, Distributed learning communities: An alternative to designed instructional system. derived from http://cudenver.edu/~bwilson, 1998.
[7] Sang-Soo Lee & Hoi-Soo Kim, "The Strategies of Building an Online Learning Community as the Practical Paradigm of Education: Focusing on an area of Gwangju and Chonnam", Korean Association for Educational Information and Broadcasting,, vol.9, no.3, 2003.
[8] Ju Sung Hwang et al, "Study of Policy for enhancing in Cyber Culture and Cyber Community", KISDI, Study Report 02-45, pp.88-89, 2002.
[9] D.P. Fulford, and S. Zhang, "Perceptions of interaction: The critical predictor in distance education" The American Journal of Distance Education. vol.7, no 3, pp.181-198, 1993.
[10] John R. Graham, Keith S. Decker, Towards Distributed, Environment Centered Agent Framework. Appearing in Intelligent Agents IV, Agent Theories, Architectures, and Languages Springer-Verlag, Nicholas Jennings, Yves Lesperance, Editors, 2000.
[11] Kohonen, Self-Organizing Maps, Springer Series in Information Sciences, vol.30, 1995; Third, extended edition, 2001.

저 자 소 개



조영임(Young-Im Cho)
1988년 고려대학교 전산과학과 학사
1990년 고려대학교 전산과학과 석사
1994년 고려대학교 전산과학과 박사
1995~1996 삼성전자 선임연구원
1999~2000 Univ. of Massachusetts, post-doc.
1996~2005 평택대학교 컴퓨터과학과 교수
2005~현재 수원대학교 컴퓨터학과 교수

관심분야 : 퍼지 이론, 신경회로망, 에이전트시스템
Phone : 031-229-8214
Fax : 031-229-8214
E-mail : ycho@suwon.ac.kr