

Giving Awareness of Maturity by Capability Assessment

Yi-Ling Kuo
National University of Tainan
Tainan, Taiwan
egmilkcherry@gmail.com

Yu Nakamura
Masayuki Sakoda
Hiroshi Tsuji
Osaka Prefecture University
Osaka, Japan
tsuji@cs.osakafu-u.ac.jp

Chang-Shing Lee
National University of Tainan
Tainan, Taiwan
leecs@mail.nutn.edu.tw

Abstract—Based on knowledge management and the spiral learning model for E-Learning, this paper proposes an interactive system, SPIral Capability Enhancement (SPICE) support system, to define two subjects: *Human Education* and *Information Security*. A student can review his situation on the subject to get feedback to evaluate his own capabilities based on comparisons. Basic idea of the proposed system originates in the pineapples of Capability Maturity Model Integration (CMMI) to allow the organizations and the systems to do the personal learning. This paper also discusses the possibility to adopt fuzzy markup language (FML) to infer the capability of maturity model which let the teachers as well as students know their capability of maturity model.

Keywords: *E-Learning; Knowledge Management; CMMI; FML*

I. INTRODUCTION

The present education system not only achieves the goal of education but also promotes student's study level. During learning process, we first have to clarify our sub-goal as well as final goal to learn and then achieve the pre-defined goals. However, teachers and learners cannot discuss with each other in any time after class, so students have sometimes difficulties in clearly finding their achievement level to the met final goal. For instance, currently teachers cannot fully obtain the level that students have learned in the class. On the other hand, students cannot share their own advices on the subject with each other. In order to make teachers much understand students' performance level, developing a computerized assessment system is important to not only provide students with after-school teaching aid but also to facilitate teachers and officials to entirely track the students' learning process [4]. If there is a system which can achieve the above-mentioned purposes, students with the low-level understanding on the subject can learn more from such as a system. Therefore, such a system with the function of sharing learning feedback with each other is highly expected to make teachers save their reviewing time assisting students after class.

This paper proposes a spiral capability enhancement learning model to solve the above-mentioned problems. In this proposed model, the steps about how to use the developed system for students are as follows: Students (1) select the subject that they studies, (2) review themselves what they are able to do or what they understands, (3) and input their advices via the learning system to be able to share with other students.

After that, the developed system shows students' learning level which have been achieved. According to the proposed model, students are able to not only review but also improve themselves through the feedback of the developed system. In this way, the involved students are capable of assisting with other students with lower maturity level and promoting their learning maturity level to the next higher one.

In this paper, the principles of Capability Maturity Model Integration (CMMI) are introduced to the SPICE [5, 6], and we called the CMMI-based spiral capability enhancement support. The main topic of this paper focuses on two SPICE applications, including human education management and information security management. Additionally, this paper also introduces the fuzzy inference mechanism to the developed system. From the simple simulation results, the proposed approach is feasible for students and teachers to understand the maturity level via the proposed CMMI-based SPICE system.

The remainder of the paper is organized as follows. Section II describes the spiral capability enhancement support system (SPICE). Section III introduces the application for human education management of SPICE system. Section IV introduces another application for the information security management of SPICE system. The simulation results of fuzzy markup language (FML) are demonstrated in Section V. Finally, conclusions are drawn in Section VI.

II. WHAT IS SPICE

A. Overview of SPICE

Fig. 1 shows the overview of the SPICE. In the model, first, a teacher analyzes the purposes of the course and divides to some circumstantial capabilities. Then he defines some maturity with them and registers to the learning system. On the other hand, a student who reviews his learning and inputs his situation with defined capabilities. At the same time, he also discloses know-how, means how he did or what he did, to the system in order to share among students. Then, the learning system judges his maturity with his inputs and defines maturity, and shows him it with what has been failed to achieve upper level and know-how given by other students. According to SPICE message, he has chance to improve himself to skill-up with these feedbacks. In this model, students repeat these three steps and can spiral up themselves

step by step. To efficiently enhance students' maturity level, it is needed to notify them their own current learning state to make students know how to do next in order to step into the next maturity level. Therefore, in this section, based on our previous work [5], the CMMI-based SPICE is introduced.

CMMI is an evaluating process method for software developing organizations [1]. It is specialized in software developing process, and currently it has been used in various fields, including national projects [2], corporate governance, and security policy. Table I shows the maturity level of CMMI is quantified with five levels. According to the definition of five maturity levels of CMMI, organizations can realize what is needed to further improve the organizational maturity. By introducing these five maturity levels to the CMMI-based SPICE, the students can promote their learning maturity level by following the defined maturity levels. The CMMI-based SPICE is an improved version of SPICE and it is easy to customize evaluation items and questions.

TABLE I. MATURITY LEVEL IN CMMI

Maturity	Stage meaning
1	Initial
2	Managed
3	Defined
4	Quantitatively Managed
5	Optimizing

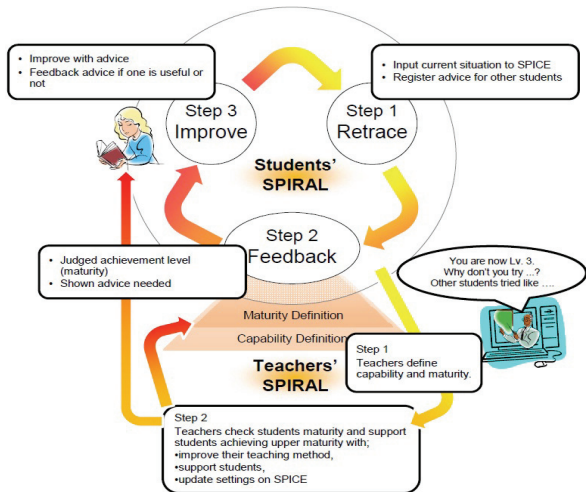


Figure 1. Overview of the SPICE.

B. Structure of SPICE

The SPICE is developed based on the maturity model of the knowledge management engineering, which is shown in Fig. 3. It operates as follows: (1) The manager extracts, defines, classifies, and then systemizes the process in order to further define the knowledge base for each application domain; (2) The defined and classified data are stored into the maturity model knowledge base to make manager acquire them; (3) The organizations and users can supervise and evaluate the current process of the activities via the system, and then stored the current activities' situation into the organization present condition management database; (4) The system also can diagnose the users' learning maturity level and how to promote to the next level, and then the diagnosis is stored into the practice know-how advice base. With the help of the SPICE, the manager and staff of the organizations can understand their own learning maturity level.

Take Fig. 2 for an example to describe the system. It is the system's screenshot to describe that there are two subjects, including human education and information security. In this figure, it indicates that the system can provide the taking-course students' list, analysis of the students' learning, and the learning maturity level of the students for the teachers.

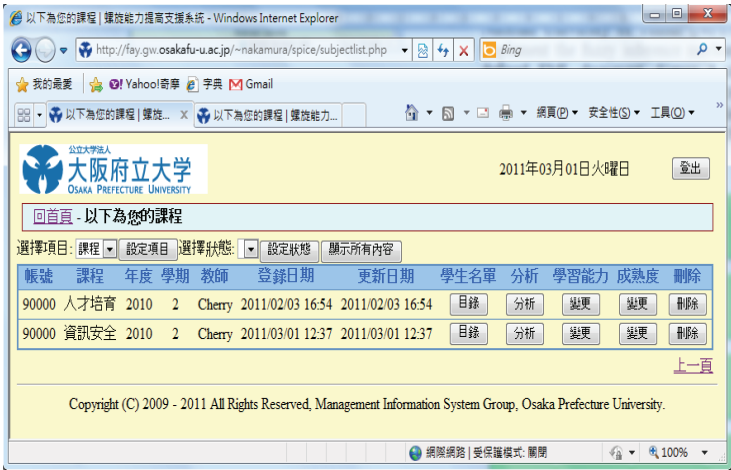


Figure 2. Screenshot showing teachers' courses.

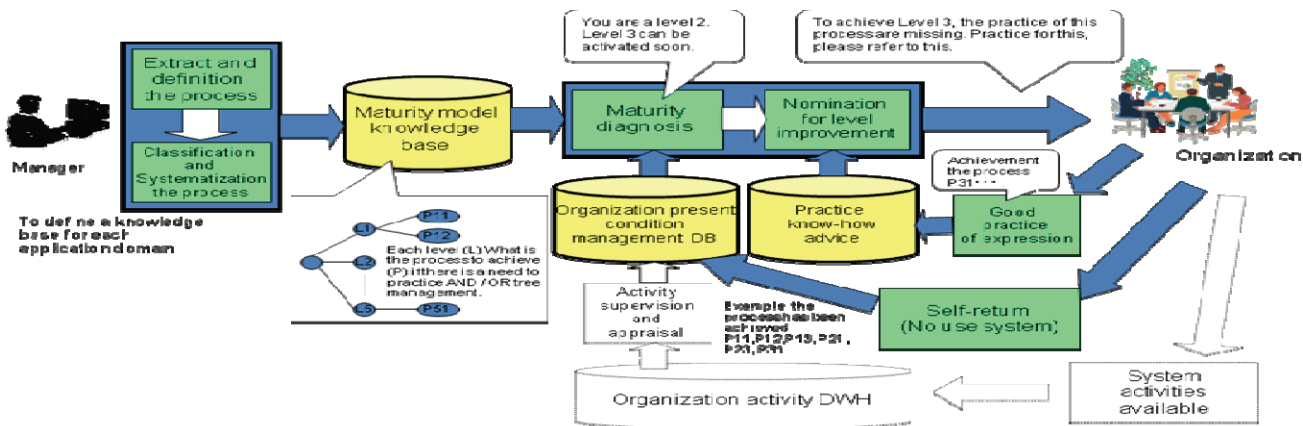


Figure 3. Process of developing the SPICE.

III. APPLICATION FOR HUMAN EDUCATION MANAGEMENT

A. Goal

The present education system should not only achieve the goal of education but also promote students' themselves study. It is necessary to clarify the achieving goal and then further attain the pre-defined goal. Therefore, five definitions of the subject human education, including technical capabilities, leadership, autonomy, cooperativeness, and responsibility, are defined in the SPICE system. With these definitions provided by the system, the teachers and students can continuously learn and share achieved goal. It is hoped that the proposed system will make as a reference for other education units in the future.

B. CMMI-based Human Education Definitions

In this application domain, according to the principles of CMMI [1], five definitions for the human education, including technical capability, leadership, autonomy, cooperativeness, and responsibility, from level 1 to level 5 are set up. Table II lists the detailed information of each definition for each level.

Following the five capability lists, we define five levels for each capability, for instance, in the technical capabilities: (L1) new technology is studied; (L2) one or more new technology is studied; (L3) new technology can be guided to others; (L4) the technology which represents the company has been developed; (L5) it continues to develop the new technology which represents the company.

Defining maturity levels as mentioned above enables teachers to understand the students learn capability and how many students on the level. Following the capability list that we define in human education subject, the students are easy to know how to achieve the level and how to step up. In addition, it is possible to refer other high-level student's advice to enhance the learn capability, the student can share knowledge with each other. Until now, we have already proposed 50 advices of human education subject. The other hand, teacher can reduce the time to educate student after school. Example interfaces are shown in Figure 4 and Figure 5.

Figure 4. Form for defining questions to evaluate human education.

Figure 5. Form for defining maturity of human education.

We also set up the ten maturities for the subject. *Maturity 1* means that students do not register the subject, so each capability value is 0. When students register the subject, they can input their learn capability and advice how they achieve to next level, that can be the advice to other students.

TABLE II. EXAMPLE OF MATURITY MODEL: HUMAN EDUCATION

Level	Technical Capabilities	Leadership	Autonomy	Cooperativeness	Responsibility
L5	The new technologies have been continuously developed by the people in the organizations.	The guided people in the organization could become one truly leader.	The people in the organization could train their employees to have the autonomy in the organization.	The imitation person it negotiates, can adjust work	The action which is responsibility social natural environment is taken
L4	The new technologies have been developed by the people in the organizations.	The guided people in the organization could propose to organize one new team and recombine the teams.	The people in the organization could check the risk of the organization in advance and take all of the possible measures.	Can do the adjustment of work also the company internal some post	The internal policy of company, it plans the conduct which is responsibility, it is possible to execute
L3	New technologies could be guided other involved people in the organizations.	The guided people in the organization could become the leadership of other more than two teams.	The people in the organization could negotiate with the people in other organizations and plan a new proposal.	You can adjust work between the team	It is possible to carry out responsibility of the team
L2	One or more new technologies are studied by the people in the organizations.	The guided people in the organization could become a leader of their own teams.	The people in the organization could set the goal to evaluate themselves each half of year.	It can adjust work inside the team	It has responsibility for own speech
L1	New technology is studied by the people in the organizations.	The people in the organization are under the guided stage.	The people in the organization could accomplish the delivered jobs automatically.	The people in the organization could finish the assigned jobs under guidance.	Still, it is rearing stage

IV. APPLICATION FOR INFORMATION SECURITY MANAGEMENT

A. Goal

Information security has gradually become one of the most important factors in the current organizations. If the internal and external information of the organizations can work well and effectively, it will enhance the whole organizations' information security to increase the organizations' work efficiency and employees' work performance [10].

Defining some capability for information security subject of SPICE system, we hope that the paper's performance will make as a reference case for other administrative units to introduce the information security in the future.

B. CMMI-based Security Management Definition

As example, we set up five maturity levels and seven capability list in information security subject shown in Table III. The basic idea is referred from Capability Maturity Model Integration (CMMI) for software developing organization [1] is an evaluating method of progress.

We set up seven capability lists for the maturity model, such as information security, personal information, data encryption, data backup, idle machinery, antivirus software, and private information. Following the seven capability list, we define five levels for each capability, for instance, in the information security: (L1) organizations don't have any information security, (L2) organization conclude the information security, but never to implement, (L3) organization conclude the information security and to implement, (L4) organization conclude the information security by themselves, and regularly to self-criticism, (L5) provide other organization to instruct the information security. Until now, we have already collected 70 advices of information security subject.

The SPICE system interfaces of information security subject are shown in Figure 6 and Figure 7.

Figure 6. Form for student list of information security.



Figure 7. Form for subject analysis of information security.

TABLE III. EXAMPLE OF MATURITY MODEL: INFORMATION SECURITY

Level	Information Security	Personal Information	Data Encryption	Data Backup	Idle Machinery	Antivirus Software	Private Information
L5	Provide other organization to instruct the information security	The computer is automaticity to turn off, when leave the computer for a long time	Use SSL(Secure Sockets Layer) to data encryption, and turn off computer when leave the seat	Regularly copy the date into CD	Don't have any idle machinery of company	Keep on the best condition everyday	Data Encryption the private information
L4	Organization conclude the information security by themselves, and regularly to self-criticism	The password is not easy to guess(Not name, birthday, phone, number plate)	Use SSL(Secure Sockets Layer) to data encryption	Regularly data backup of memory, USB drive and hard discs	Before sell and recycle, the data already delete of the idle machinery	Drawing off the web line immediately, when the computer is poisoned, and delete it	Never send the private information by e-mail
L3	Organization conclude the information security and to implement	The employee autonomy and regularly to change the password	Before mail, any information are encryption	The employee autonomy to data backup	Follow the regulation to sell and recycle the idle machinery	Buy the antivirus software to set up	Never open the private information on public computer
L2	Organization conclude the information security, but never to implement	The boss required to change the password	Mail the personal information are encryption	The boss required to data backup	Sell and recycle the idle machinery	Set up the antivirus software from internet	Security to store up the private information
L1	Organizations don't have any information security	Never change personal password	Mail the information that no be encryption	Never data backup	No properly to deal with the idle machinery	No antivirus software to set up of computer	No security to store up the private information

V. FUTURE PERSPECTIVE BASED ON FUZZY MARKUP LANGUAGE

As future perspective, let us combine our previous fuzzy inference model with FML to describe the knowledge base and rule base of the Spiral Capability Enhancement Support System. Figure 8 shows the structure for Human Education of the Spiral Capability Enhancement Support System.

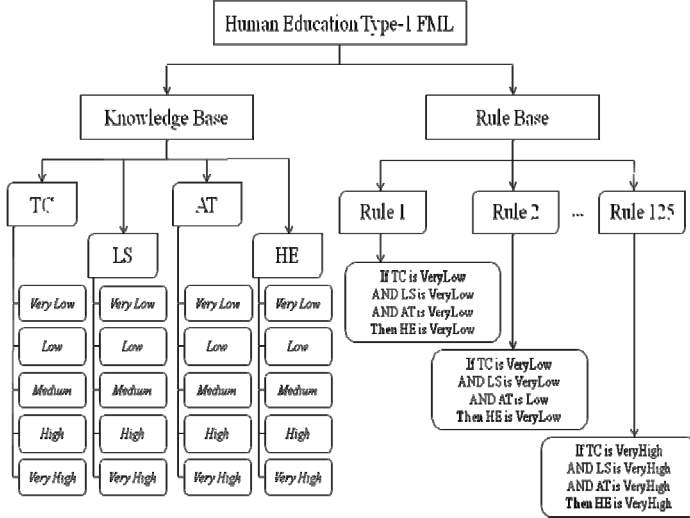


Figure 8. Membership functions of the fuzzy variables TC, LS, AT, and HE.

FML is a fuzzy-based markup language that manages fuzzy concepts, fuzzy rules, and a fuzzy inference engine [3, 8, 9].

There are three input fuzzy variables Technical Capabilities (TC), Leadership (LS), and Autonomy (AT) as well as one output fuzzy variable Human Education (HE) defined for the fuzzy reasoning mechanism. For fuzzy variable TC, LS, AT and HE, there are five linguistic terms are defined, including VeryLow, Low, Medium, High and VeryHigh. The brief descriptions of TC, LS, AT and HE are mentioned as follows:

- **TC:** The Technical Capabilities of company that develops new technology.
- **LS:** Leadership capabilities of team, including responsibility.
- **AT:** To accomplish the schedule of team, including negotiation with other company.
- **HE:** It represents the term relation strength. Based on the values of the *TC*, *LS*, and *AT*. *HE* is the inferred term relation strength of the term pair.

Herein, a FML editor, developed by the Ontology Application & Software Engineering (OASE) Laboratory, National University of Tainan (NUTN), Taiwan, will be used to implement the fuzzy inference mechanism based on the pre-defined FML document. Figure 9 shows the example membership functions of the fuzzy variables TC, LS, AT and HE. Figure 10 shows the structure of the adopted rule-based fuzzy inference mechanism. Table IV lists the adopted fuzzy rules.

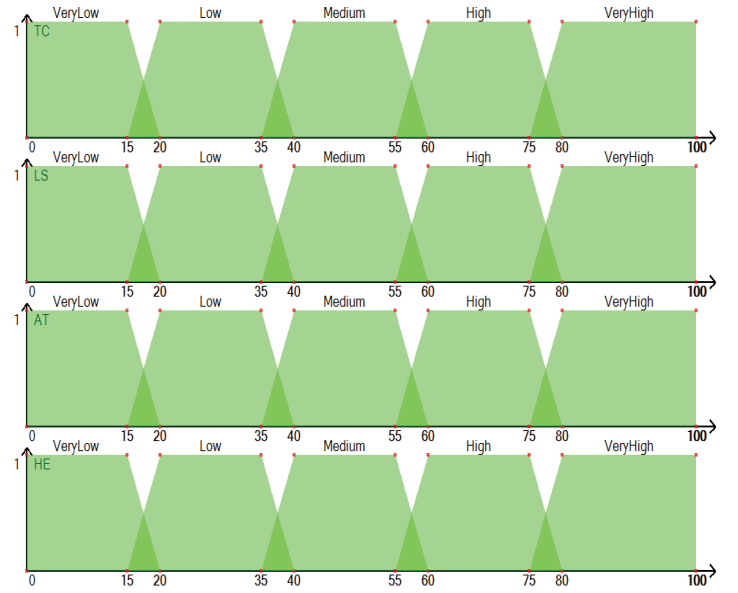


Figure 9. Membership functions of the fuzzy variables TC, LS, AT, and HE.

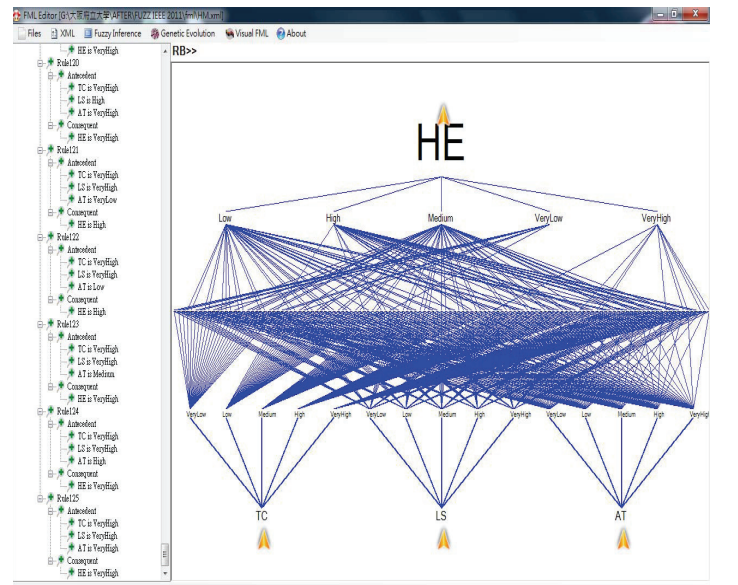


Figure 10. Structure of the adopted rule-based fuzzy inference mechanism.

TABLE IV. ADOPTED FUZZY RULES

Rule No	Fuzzy Variable				Rule No	Fuzzy Variable			
	TC	LS	AT	HE		TC	LS	AT	HE
1	VL	VL	VL	VL	69	M	H	H	H
2	VL	VL	L	VL	70	M	H	VH	H
3	VL	VL	M	VL			...		
4	VL	VL	H	L	96	H	VH	VL	M
5	VL	VL	VH	L	97	H	VH	L	H
		...			98	H	VH	M	H
36	L	M	VL	L	99	H	VH	H	VH
37	L	M	L	L	100	H	VH	VH	VH
38	L	M	M	L			...		
39	L	M	H	M	121	VH	VH	VL	H
40	L	M	VH	M	122	VH	VH	L	H
		...			123	VH	VH	M	VH
66	M	H	VL	L	124	VH	VH	H	VH
67	M	H	L	M	125	VH	VH	VH	VH
68	M	H	M	M					

VL: VeryLow, L: Low, M: Medium, H: High, VH: VeryHigh

VI. CONCLUSION

In this paper, a CMM-based E-Learning system has been proposed and applied spiral capability enhancement learning model as a new learning model. In this model, a student has chance to review himself what or how he learned, to get feedbacks from the learning system, and to improve himself with these feedbacks to enhance his capability. At the same time, a teacher is allowed to check students' achievement level and can ameliorate a way to teach.

This paper proposes the fuzzy markup language (FML) to apply to human education and information security. In the future, we hope to refer the method of expert to define the genetic fuzzy markup language (GFML), and to devise the distinct rules that refer to other organizations.

ACKNOWLEDGMENT

The authors would like to thank the involved classmate of Osaka Prefecture University (OPU) and National University of Tainan (NUTN) for their joining this research project. The authors also would like to thank the National Science Council of Taiwan for financially supporting this international NSC99-2622-E-024-003-CC3.

REFERENCES

- [1] M. B. Chrissis, M. Konrad and S. Shrum: "CMMI for Development, Version 1.2" <http://www.sei.cmu.edu/cmmi/tools/dev/download.cfm> (Accessed on Mar 14, 2011)
- [2] M. Sakoda, Y. Wada, H. Tsuji and K. Seta: "Social Network Service with Maturity Level for Science Teachers", Proc. of IEEE International Conference on Systems, Man and Cybernetics, pp. 1718–1723, Texas, USA, 2009.
- [3] G. Acampora and V. Loia, "Fuzzy Control Interoperability and Scalability for Adaptive Domotic Framework," IEEE Transactions on Industrial Informatics, vol. 1, no. 2, pp. 97–111, 2005.
- [4] M. H. Wang, Z. R. Yan, C. S. Lee, P. H. Hung, Y. L. Kuo, H. M. Wang, and B. H. Lin, "Apply fuzzy ontology to CMMI-based ASAP assessment system," 2010 IEEE World Congress on Computational Intelligence (IEEE WCCI 2010), Barcelona, Spain, Jul. pp. 18-23, 2010.
- [5] Y. Nakamura and H. Tsuji: "Spiral Capability Enhancement Support System". Aware Computing (ISAC), 2010 2nd International Symposium on Aware Computing (ISAC 2010), Tainan, Taiwan Nov. pp. 233-238, 2010.
- [6] Y. Nakamura, H. Tsuji and Y. Majima: "General Purpose E-Learning Engine Based on Capability Maturity Model Integration and SECI Model" Japan-Cambodia Joint Symposium on Information Systems and Communication Technology(JCAICT 2011), pp. 121-122, 2011.
- [7] C. S. Lee, M. H. Wang, and J. J. Chen, "Ontology-based Intelligent Decision Support Agent for CMMI Project Monitoring and Control," International Journal of Approximate Reasoning, vol. 48, no. 1, PP. 62-76, 2008.
- [8] C. S. Lee, M. H. Wang, G. Acampora, C. Y. Hsu, and H. Hagra, "Diet assessment based on type-2 fuzzy ontology and fuzzy markup language," International Journal of Intelligent System, vol. 25, no. 12, pp. 1187-1216, Dec. 2010.
- [9] C. S. Lee, M. H. Wang, S. J. Yen, Y. J. Chen, C. W. Chou, G. Chaslot, J. B. Hoock, A. Rimmel, and H. Doghmen, "An ontology-based fuzzy inference system for computer Go applications," (SCIE) International Journal of Fuzzy Systems, vol. 12, no. 2, pp. 103-115, Jun. 2010.
- [10] C. S. Lee, Y. L. Kuo, Y. L. Wang, H. T. Liang, Y. W. Lin, Y. L. Chen, M. H. Wang, and M. Y. Ju, "A Study on CMMI-Based Information Security Management System" Journal of National University of Tainan, vol. 44, no. 2, pp. 61-88, Oct. 2010.