

Web-based e-learning and virtual lab of human-artificial immune system

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Abstract: Human immune system is as important in keeping the body healthy as the brain in supporting the intelligence. However, the traditional models of the human immune system are built on the mathematics equations, which are not easy for students to understand. To help the students to understand the immune systems, a web-based e-learning approach with virtual lab is designed for the intelligent system control course by using new intelligent educational technology. Comparing the traditional graduate educational model within the classroom, the web-based e-learning with the virtual lab shows the higher inspiration in guiding the graduate students to think independently and innovatively, as the students said. It has been found that this web-based immune e-learning system with the online virtual lab is useful for teaching the graduate students to understand the immune systems in an easier way and design their simulations more creatively and cooperatively. The teaching practice shows that the optimum web-based e-learning system can be used to increase the learning effectiveness of the students.

Keywords: Human immune system; web-based e-learning; visual lab; artificial immune system

INTRODUCTION

Human immune systems are crucial for the health of everyone, and these systems make us survive from the diseases and disasters. Inspired from the human immune systems, the artificial immune system is used to protect the computers and networks, and the artificial immune system is a new subset of intelligent systems. To help students, scientists and doctors to understand the human-artificial immune system, the course *intelligent system control* (ISC) in Donghua University is used as the testbed for new modeling and teaching approach of computational immunology. This course is of plentiful abstract knowledge and generally difficult to understand for the students (Gong and Cai, 2006), so this course is difficult to teach with some traditional teaching approaches. For example, the mathematical model for the process of aggregation in immune agglutination is built on the three differential equations (Ming *et al.*, 1965). This model is difficult for the students to understand, because it has no any visual simulation.

Besides, traditional teaching approaches did not provide enough examples to aid students in understanding the knowledge about the immune systems and design their own simulation programs of the immune systems. Then for the students this course became unpractical to understand the real immune systems.

To make this course easier to teach and learn, we develop an immune e-learning model with the virtual lab for this course, and then build a web-based immune e-learning

system of this course. This new modeling and teaching approach is useful to help the students to understand the immune system and the relative pharmacology better.

In this paper, the case teaching, the e-learning, the online virtual lab and the immune computation are used to improve the teaching effectiveness of this course in universities. With the immune e-learning model and the virtual lab, this web-based immune e-learning system is becoming an advanced artificial immune system and educational system.

In the field of the artificial immune systems, Balthrop and Forrest *et al.* discussed the harmful spread of viruses and investigated immune computation techniques (Balthrop *et al.*, 2004). Bersini designed some immune algorithms to solve problems in the adaptive network (Bersini and Varela, 1991). Ishida used artificial immune system to solve the fault diagnosis problem of sensor network (Ishida, 1990).

Inspired from the human immune system, the immune computation mechanism makes the web-based e-learning system for this course robust, like a strong man with vaccines.

Web-based immune e-learning model with virtual lab of the course about immune systems

According to the main features of graduate students, the graduate student model is utilized to establish the web-based immune e-learning model. This immune e-learning model consists of the graduate student module based on the graduate student model, the professor module, the

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administrator module and the common module, as shown in fig. 1. The tri-role structure includes the graduate student module, the professor module and the administrator module, and the three modules are respectively used by the graduate students, the professors and the administrators. In fig. 1, the graduate student model of this graduate student module is comprised of important knowledge about the immune systems and the learning skills for the students.

In fig. 1, the theoretic knowledge is the basic part of one graduate student' knowledge structure, and some traditional classroom- based teaching methods can also provide this kind of knowledge to the students. But the

traditional teaching methods cannot provide a virtual platform to show how the students can design some hardware or software to verify the theoretic knowledge about the immune systems. So the creative thinking of the students cannot be activated and trained. Because there is no online experiment in the classroom, there is also no failure in the experiment for the graduate students. Then the graduate students cannot know how to face with the difficulty and failure in the experiments by adjusting their attitudes. It is important that this immune e-learning system can do this, with online visual experiments. The graduate students can do the designs by themselves to show their creative thinking and accumulate the experience about the methodology and the attitude

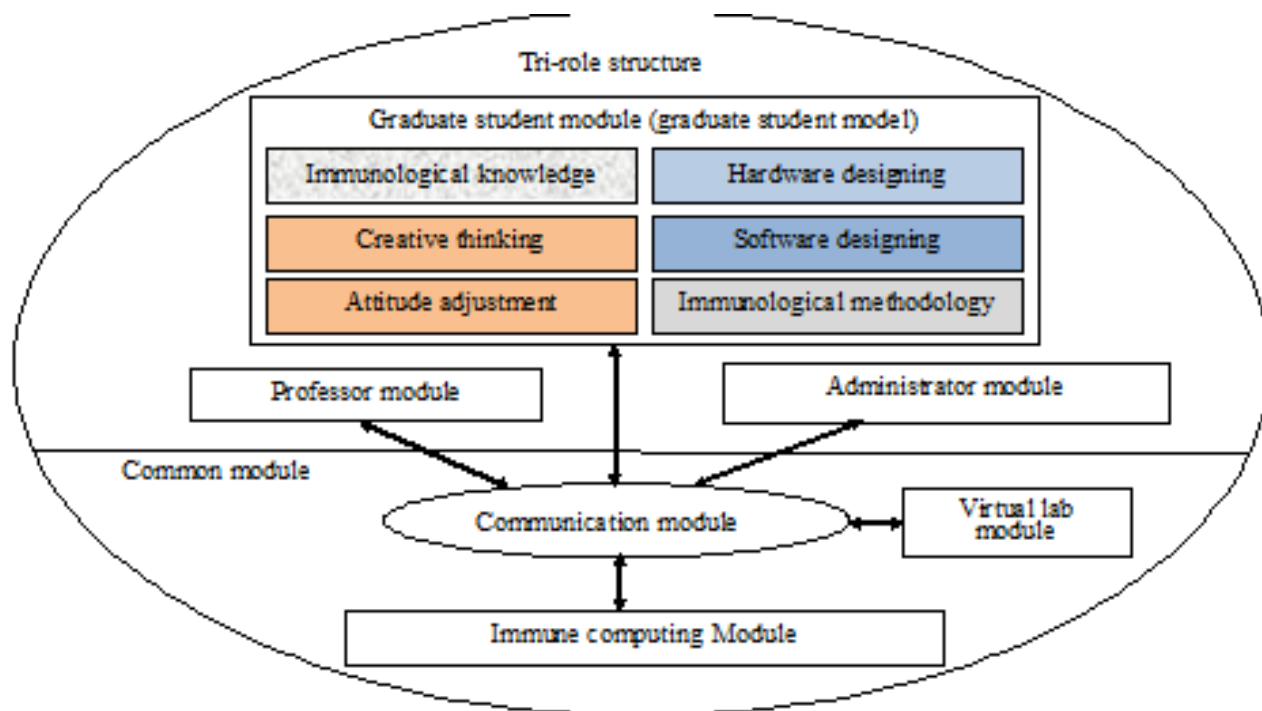


Fig. 1: Web-based immune e-learning model of the graduate students for this course.

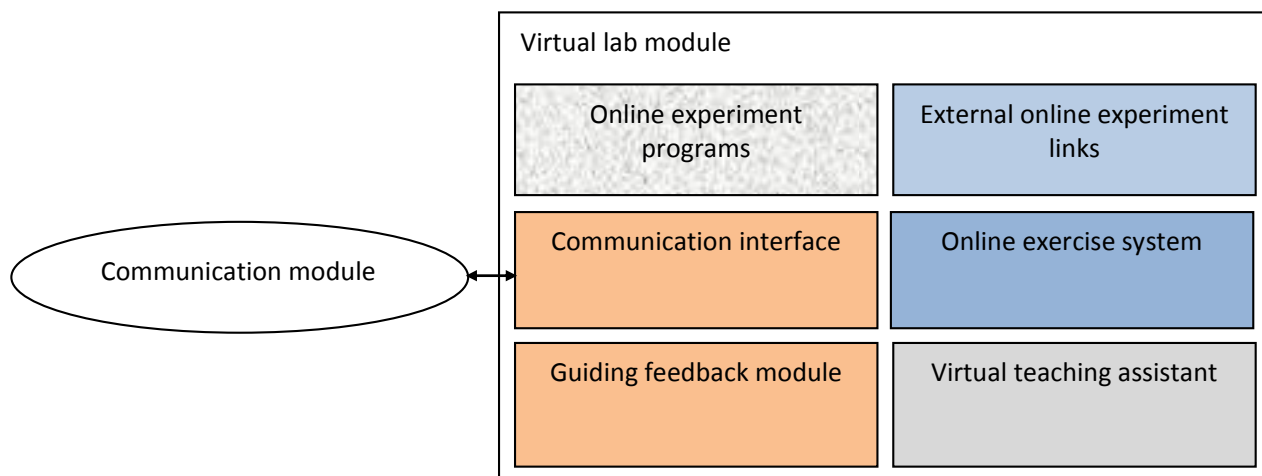


Fig. 2: Virtual lab model of this intelligent system control course for the graduate students.

adjustment. After this web-based immune e-learning system is attacked by some viruses or has some software faults, its immune computing module will be activated and communicate with the cloud center of immune computing. This web-based immune e-learning system is an intelligent immune baby swimming in the knowledge sea.



Fig. 3: First web page of this course.

The virtual lab module is a crucial part of the common module to activate the creative thinking of the graduate students. This virtual lab module is used as a web-based simulation platform to provide many online simulations of the immune systems, and the virtual lab can guide the graduate students to understand the immune systems better. The virtual lab model is comprised of the Java-Applet-based online simulation programs, the external

online experiment links, the virtual teaching assistant, the online exercise system, the guiding feedback module, and the communication interface, as shown in fig. 2. The online simulation programs are designed as an inspiring demo for the graduate students to aid the understanding of the abstract knowledge nodes about the immune systems. The communication interface is a bridge between the virtual lab module and the communication module to connect the virtual lab and the graduate students together. The online exercise system is utilized to test the learning progresses of the graduate students after each chapter. The guiding feedback module is designed to adaptively guide the graduate students to learn new knowledge according to their own learning progresses. The virtual teaching assistant is the humanoid interface between the web-based immune e-learning system and the graduate students. This virtual teaching assistant has the humanoid appearance like an immune baby to let the graduate students feel it as a friend, who has much guiding information. Such information is used by students to learn new immunological knowledge as they need.

Teaching practice and experimental validation

The intelligent system control course is related with knowledge representation and reasoning, optimal search, expert system, immunology and immune computation, fuzzy control, genetic algorithm, neural network, machine learning and so on. The immune system webpage of this online course is started from the first, as shown in fig. 3.

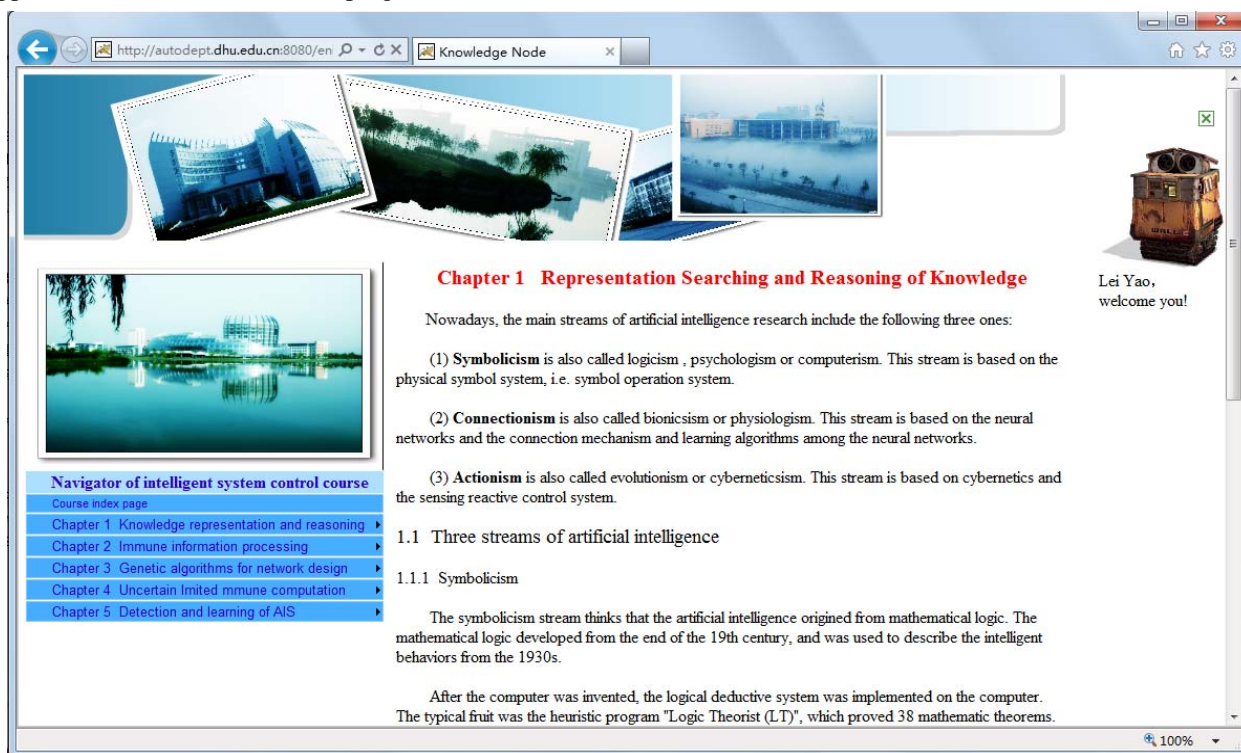


Fig. 4: Knowledge node web page of the knowledge representation and reasoning in this course.

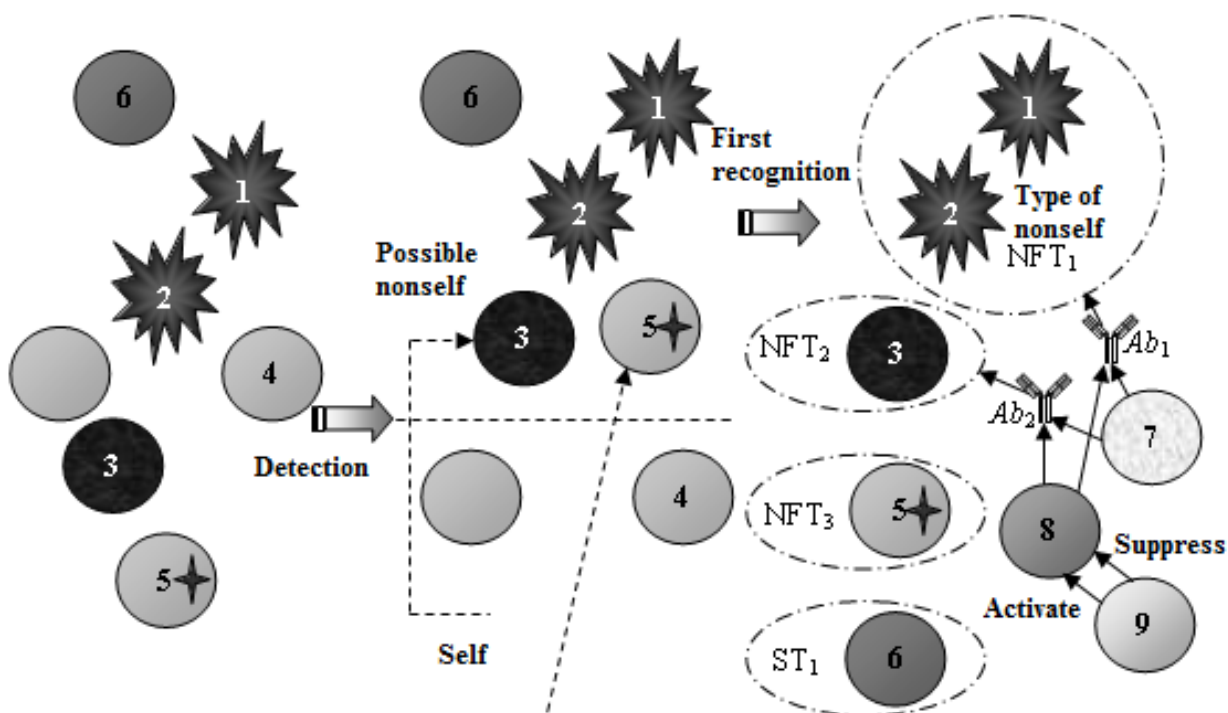


Fig. 5: Knowledge node of the innate immune system in this course.

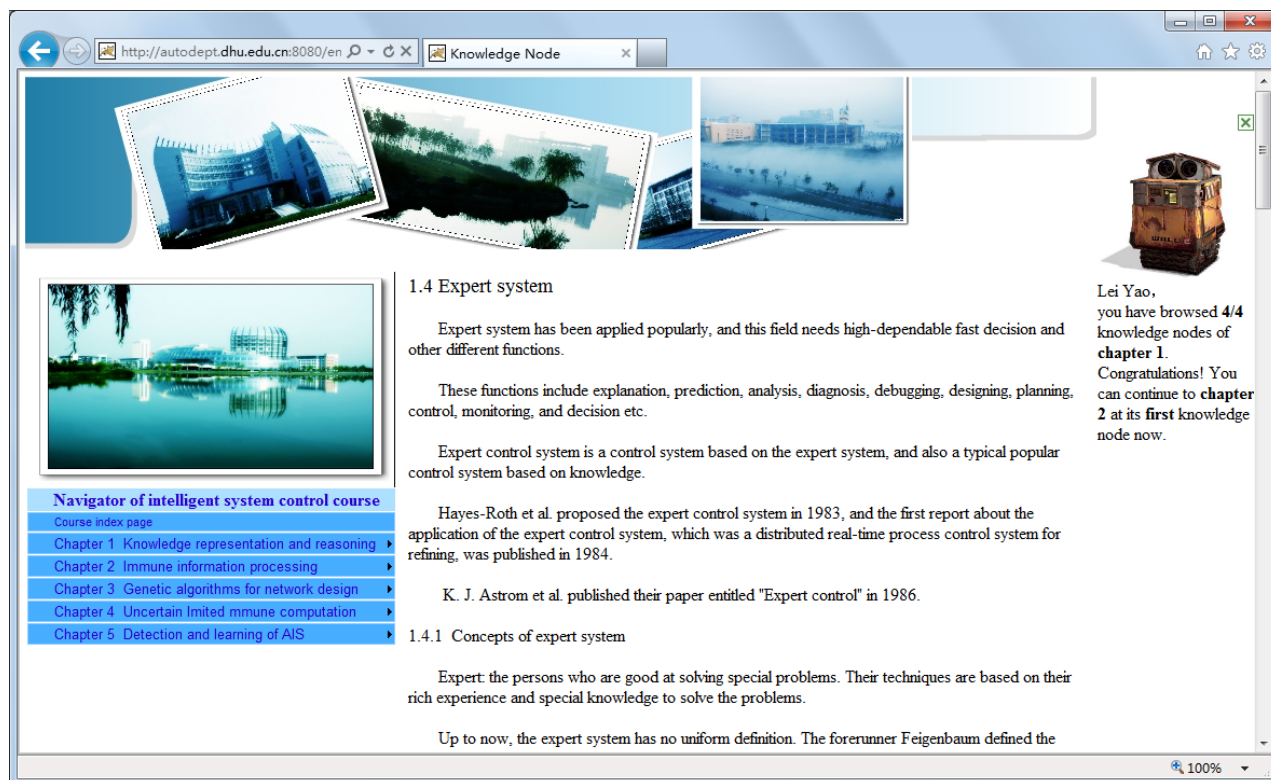


Fig. 6: Intelligent teaching assistant about the innate immune systems in this course.

After the user is granted to use the online course system, this user can learn the knowledge node web page of the knowledge representation and reasoning, as shown in fig. 4 and the knowledge node of the innate immune system,

as shown in fig. 5. As we can see in these figs, the left is the navigator of this intelligent system control course. Each chapter has some sessions and each session has at least one knowledge node.



Chapter 1 Representation Searching and Reasoning of Knowledge

Nowadays, the main streams of artificial intelligence research include the following three ones:

(1) **Symbolicism** is also called logicism, psychologism or computerism. This stream is based on the physical symbol system, i.e. symbol operation system.

Fig. 7: Discussing pattern of this intelligent teaching assistant.

Fig. 8: Virtual lab of this course.

In fig. 5, the known virus No. 1 attacks the body, which has the corresponding antibody to this virus. The body is immune against this virus and can recognize this virus quickly to eliminate this virus as soon as possible. At the same time, the cell 5 has gene pathology, and the gene pathology is unpredictable. In the stage of the innate immune response, the self/nonself detection mechanism is used to discriminate the selfs and the possible nonselfs.

Cell 4 represents the normal cell, and the cell is a self. The antibodies Ab1 and Ab2 are produced by the B-cell 8 and this B-cell 8 is activated and suppressed by the cell-T.

When the student browses a web page of the knowledge node, the filename of this page will be added into the

learning history of this student. After this student arrives at the end of a chapter, the intelligent teaching assistant, as shown in fig. 6, will show the learning progress of this student in the chapter. This intelligent teaching assistant has a cartoon shape of robot and can discuss with students and teachers. After the user moves the mouse onto this intelligent teaching assistant, this robot will use the discussing pattern, as shown in fig. 7.

The online discussing function is supported by such online messaging software as QQ, which is the popular web communication tool for many users in China (Lau *et al.*, 2009). The intelligent system control course not only has the intelligent teaching assistant, but also has an online virtual lab, as shown in fig. 8.

In this virtual lab, there are six experiments, which can help the graduate students to better understand the knowledge representation, problem-solving, algorithm design and system debugging (Juang and Lu, 2006). The right windows show some typical examples of virtual experiments, such as the Hanoi Towers demo and the fuzzy control demo.

CONCLUSIONS

The intelligent system control course is necessary and helpful for graduate students, whose majors are related with the immune systems. It took about one year to develop this web-based immune e-learning system with online virtual lab. In this course, many graduate students have used this course system. At the end of this course, this course system was assessed excellent by the graduate students of Donghua University. These new immune models and teaching approaches can be used in many universities in the world to improve the understanding of the immune systems. This course system also provided testing platform for intelligent techniques, so the graduate students can use this platform to share experience and knowledge in this field. As the students said, the advanced functions of immunity and security can be improved by both the teachers and the students.

From this course system of intelligent system control, we know that the web immune e-learning system based on the virtual lab is important and necessary for the educational web. First of all, the immune e-learning model and the virtual lab model should be built on some educational rules. Then, some educational experiments can be made in the campus network with the help of the graduate students. At last, the prototype of this immune e-learning system has already been verified to outperform the traditional teaching methods that are effective only in the classroom.

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