Development of an Interactive Circuits and Systems Seminar (iCASS) and its effectiveness

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In this paper, we describe a development of an interactive educational tool in Circuits and Systems (iCASS) and its introductory effect to the College of Technology. The purpose of this tool is to help teacher's lecture and student's self-learning. This tool can be used for on-line learning, can be easily integrated into an E-Learning platform for distance learning, and can be used in the classroom with notebook computer and over-head projector, via Internet or CD-ROM. For the purpose of implementation, we produce a set of teaching materials using HTML text and Java Applets for interactive animation. As a result, the proposed tool can be used as a self-learning tool independent of time and working place. Moreover, in this tool, the movement of the engineering model isn't only seen, but hearing as sound is also very effective in study. Futhermore, this tool might be canceled "squiffy doo" of the simulation by connecting an actual model and computer. We describe that the proposed tool has an effect for interest attachment to students and allow to speed up the learning process. The E-Leaning tool as presented at the conference can be found at http://www.sia.co.jp/~icass/index.html.

Keywords: E-Learning, IT, education tool, education effect, iCASS

1. Introduction

There is a lot of discussions about the student of the declining academic standards. A new method of teaching will help to make these subjects more attractive to students [1],[2].

Generally, it is difficult for the student (beginner) to understand intuitively the "Movement" of the engineering model as it is a complex technological issue, which obstructs the learning process of student towards scientific and technological knowledge. For example, the use of space- and time-dependent vector-valued functions to describe the behavior of the current and the voltage in electric circuits raises many difficulties. In the electric and electronic engineering, experiential learning by the experiment and the practice is being enforced to suggest the understanding of the various phenomena (the "Movement" of the model). The advantage of the learning by the experiment and the practice can't only experience the "Movement" of the model, and might be the

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following :
(1) The sense understood to manufacturing such as "preparation", "production", "verification" and "a consideration" can be developed.
(2) The student can support the ability that Abstract physics phenomenon is caught quantitatively and data is brought together as other people understand.

On the other hand, there are the following disadvantages in the experiment and the practice to treat the physical phenomenon.
(1) Many actual working hours are necessary.
(2) It is difficult for the learner easily to execute, and to study the experiment and the practice by oneself.

As one method of solving this problem, there is a virtual experience by the simulation using EDA (Electronic Design Automation) tool. The advantages of simulation are the flexibility which comes from having a system implemented in a general manner, and less expensive. However, the student would need some feeling for the hardware which is necessary to make useful simulations.

Recently, because of the underlying software technology the tool can be used for on-line learning and can be easily integrated into E-Learning platform for distance learning [3],[4]. It can be also used in the traditional classroom with notebook computer and over-head projector, via Internet or CD-ROM. An advantage

of E-Learning is the independence of working place and time. Futhermore, if the content can be presented in the web-browse and programs as like simulation and/or animation are able to run inside a web-browser, the dependency of the software on the operating system can be eliminated. At the ETH Zurich modern teaching and E-Learning tool has been developed. This tool is called iPES and is constituted by HTML text with Java-applets.

We describe a development of an unique web-based interactive animation software for teaching and self-learning electric circuits like iPES [3]. In this paper, we call an interactive education tool in circuits and systems (iCASS). Sound is used besides the interactive animation in iCASS. Moreover, iCASS might be canceled "squiffy doo" of the simulation by connecting an actual model and computer. By using iCASS for the actual classroom, effective that the interest and the understanding of the student improve is shown. Consequently, iCASS has an effect for interest attachment to students and allow to speed up the learning process.

2. Aim of system development

iCASS is an unique web-based education tool by using interactive animation and sound. This system is the independence of working place and time. Hence, the students have the opportunity to learn in their favorite environment at the time of their choice. Moreover, this system might be canceled "squiffy doo" of the simulation by connecting an actual model and iCASS. In figure 1, the concept of the proposed system is shown and those details are as follows.

（1） Visualize a movement of models

Generally, it is difficult for the student to understand the "Movement" of the engineering model intuitively. It is difficult to learn knowledge concerning technology and a sense as that result. Furthermore, it is difficult to express the "Movement" of the engineering model and complex scientific and technological issues in a conventional class using a black board which is restricted to static diagrams and words only. The system to be described shows dynamic behavior and/or a lot of different possible states do occur teaching becomes difficult for the instructor in case only words and static pictures are at hand. Consequently, interactive animation can help a lot. For example, the paramters on model can be changed easily by using graphical user interface. Especially, the value of element is represented in the size of its element in the proposed tool and it becomes help of intuition for the student.

（2） Effective use the sound

The "movement" of the engineering model isn't only watched, but hearing as sound is also very effect for attractive to student. That is, the tool having the sense of fun gives the student the interest. For example, if resonance frequency in a resonant circuit is changed, sound like the channel of radio changes. Moreover, if the "width" of
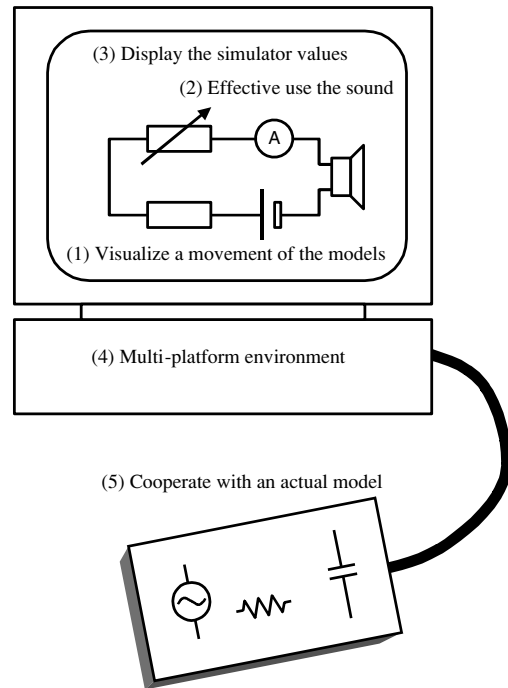

Fig. 1. The concept of iCASS tool

the frequency response in the resonant circuit has wide; It has low frequency selectivity. That is, if resonant circuit is lower quality factor Q, sound interferes. Thus, it becomes experience very good for a student that the frequency characteristic and sound change simultaneously.

（3） Display the simulator values

The "Movement" of an engineering model is intuitively understood from displaying animation. However, emphatically displaying the changing physical value will teach wrong knowledge for the student. Therefore, in this teaching tool, we display the result of the correct calculation by using theoretical formula. That is, it might use as a simple EDA tool because it can display the result of obtaining by the simulation. Moreover, the student set circuits parameters without explicitly starting a simulation and immediately see the resulting behavior of various currents, voltages and signals.

（4） Multi-platform environment

If the content can be presented in the web-browse and programs as like simulation and/or animation are able to run inside a web-browser, the dependency of the software on the operating system can be eliminated. The tecnology which dose it make possible to run programs in web-browsers is Jave. Moreover, Jave programs running inside web-browser are embedded in HTLM page and are called Java-applet [7], [8]. Therefore, iCASS is constituted by HTML text with Java-applets for interactive animation, sound, circuits design and simulation, and visualization.

（5） Cooperate with an actual model
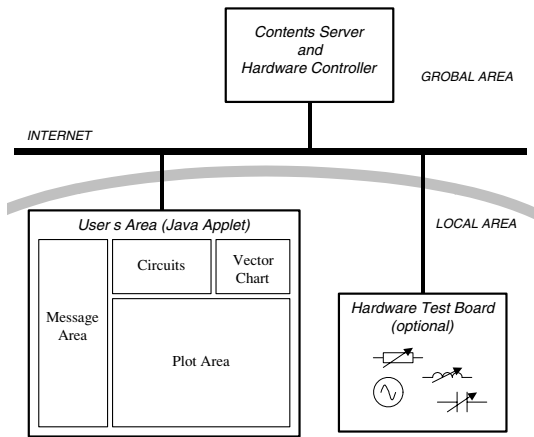
Most teaching tools using a priviously IT-

Fig. 2.　System structure

technologies perfom only simulation on the computer. However, in the field which is easy to obtain an actual model like electric circuits and systems, the teaching tool using both the simulation and the actual model is useful for a student. That is, intuitively imaging the phenomenon without "squiffy doo" of the simulation becomes possible. Consequently, this tool connects a actual electric circuit model and iCASS by Ethernet as shwon in figure 2. As a result, the animations of Web (size of elements and response) also interlock and change, when resistor, inductor and capacitor in the actual electric circuit model is changed. Here, in order to connect an actual electric circuits model and iCASS, we use PIC, (Peripheral Interface Controller), NIC, (Network Interface Card), as shown in figure 3. Moreover, in order to control PICNIC, we use JSP (JavaServer Pages). Here, JSP is a technology based on the Java language and enables the development of dynamic web sites. JSP files are HTML files with special Tags containing Java source code that provide the dynamic content.

3.　Contents of iCASS

iCASS provides an excellent basic for teaching an introductory course on electric circuits including the subjects listed in the following:

 (1) Fundermental electric circuits
 (2) DC circuits
 (3) Sinusoidal wave and complex plane
 (4) AC circuits
 (5) AC power
 (6) Resonant circuits
 (7) Mutual induction circuits (waiting)
 (8) Matching circuits (waiting)
 (9) Bridge circuits (waiting)
 (10) Transient phenomena (waiting)
 (11) Fourier series (waiting)
 (12) Fourier transform (waiting)
 (13) Distribution circuits (waiting)

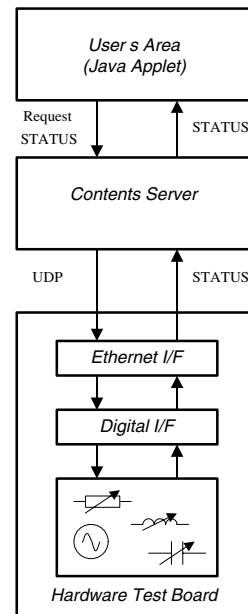The contents of "waiting" indicator will be completed in the near future.
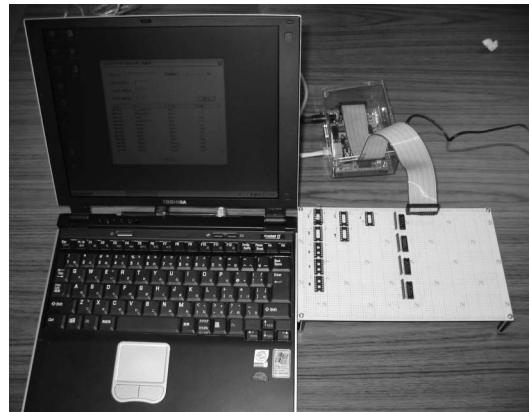

Fig. 3.　Control method of obgect model

Fig. 4.　Connection with the practical model

Fiure 4 shows a connection the actual electric circuits model with iCASS. The actual electric circuit on circuit board consits of 8 IC sockets and simple logic circuits. By connecting a socket as shown in a figure 5 to the socket on a board, various circuits are realizable. Where elements, such as resistor, inductor and capacitor are connected to 1-1' terminal of the IC sockets as shown in figure 5.In addtion, the kind of the element is represented by the open circuit or short circuit of 2-2' and 3-3' terminals, and the value of the element is represented by the open circuit or short circuit of 4-4', 5-5', 6-6' and 7-7' terminals, Hence, in order for a World Wide Web (WWW) system and an actual model to interlock, the state of IC socket shown in a figure 5 should just be known. Only 4 bits are used to indicate the element value in iCASS, but you can use many number of bits to indicate many element values if you want to use many element value.

4.　Example of iCASS

As an example of iCASS, the example of WWW system dealing with a series resonant circuit is shown in
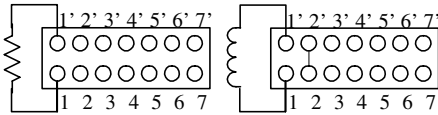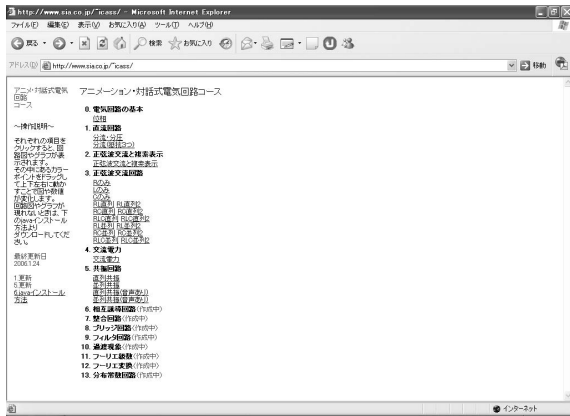
Fig. 5.   Structure of IC socket

Fig. 6.   Main menu of iCASS

Fig. 7.   An example of the teaching materials (Resonance)

Fig. 8.   An example of the teaching materials (Movement by changing elements)

figures 7 nad 8. In the circuit of figure 7, the graphical user interface of the applets is very intuitive as like iPESS. the general role (with some exceptions) is: One can click or drag all colored round mark with mouse as well as iPESS. In order to give the student an intuitive image, there is no function of a numerical input at ICASS and the value of an element is imagined in the size of an element. Namely, the student can interactively influence parameters. In the series resonant circuit, when circuit elements (R, L, C) are changed, it is important to understand how resonance frequency, quality factor and current change. The student can change the each element value as shown in figure 8 by simply dragging the colored round mark of resistor, inductor and capacitor, as shown in figure 7, with the mouse, and can immediately see the appearance of the change in the resonace frequency and quality factor. Because the colored round mark is also set up in the characteristic frequency curve, when the characteristic is dragged with a mouse, it is shown how each element value at the circuit changes. Moreover, the role of resonance and the quality factor can be felt to "sound" in iCASS. In figures 7 and 8, three channels are prepared, and if the channel is matched to the resonance frequency, sound can be heard most greatly. In addtion, it is important to understand that circuits possessing a higher quality factor Q have a narriwer bandwidth, or a sharper response curve; they have greater frequency selectivity or higherquality factor. For example, if a quality factor q is small, the student can feel to sound that interference between chanels will occur.

The size of each element and the resonance characteristic on the screen synchronize and change, when the actual model is connected and the each element value of the resistor, inductor and capacitor on the its model is changed. Here, you note that the size of element and the resonance characteristic on the WWW system become "discrete movements" corresponding to
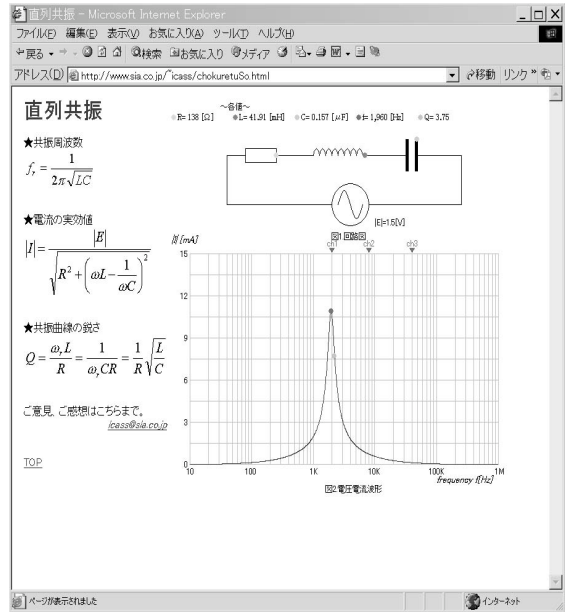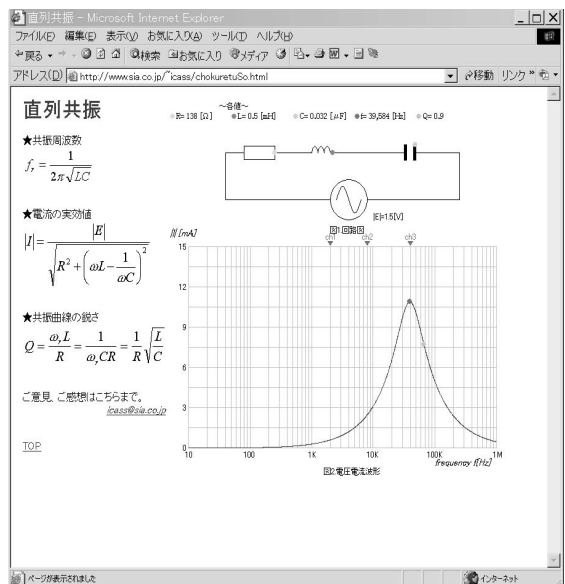
these value, since element values can represent only eight kinds in iCASS. By connecting an actual model, the student might become possible not only like an intuitively recognize but also experiment for the relation between an element value and the characteristic. Furthermore, the measuring instrument is also connectable with iCASS. Then, because the display on WWW and the display of a measuring instrument become the same, this system might be canceled "squiffy doo" of the simulation. Moreover, it can use also as a simple design tool (EDA).

iCASS is comprised by Java applets embedded into HTML pages. The text explaining the theory is written in simple HTML. The student might use as a self-leaning tool without depending on working place and time.
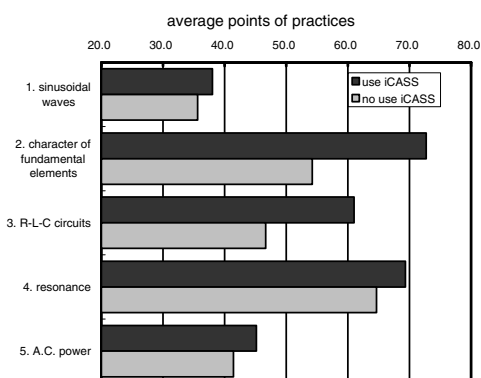
average points of practices

Fig. 9. An evaluation of iCASS (Average points of practices)

Fig. 10. An evaluation of iCASS (Progress points for each student)

5. The educational effect of iCASS

In this section, the educational effect with iCASS is examined an actual class.

In order to show the educational effect with iCASS, the lesson with iCASS and without iCASS were performed to the same student for 45 minutes, respectively, and the exercise is solved after each lesson. Here, although the student attend the same lecture twice, it is different which lecture is attending previously itveach time. In the lecture with iCASS, it is assumed the class that the teacher operated iCASS. Figure 9 shows the evaluation average point of the exercise. It is clear from this figure that the evaluating point of the lesson with iCASS is better than the evaluating point of the lesson without iCASS in 5 lessons. Especially,the improvement in results of the lecture for the character of fundamental elements and series-parallel circuit is remarkable. In circuits that contains inductor or capacitor, the deviation of the phase between current and the voltage can be understood by animation of iCASS. Figure 10 shows the improvement result of the point of each student.The improvement is seen by 11 in 14 students.

To know an intuitive image of iCASS, it questioned students as follows, and it answered by five stage evaluation.
（1） Do you improve the degree of the interest to electric circuit ?
（2） Do you improve the understanding to electric circuit ?
Table 2 shows result of the questionnaire. Where it means that evaluation 5 improved most and evaluation 1 fell. It is clear from table 2 that iCASS is effective in improvement in consciousness to a student.

iCASS can not only make studying more attractive to student, but might make also teaching more effective. the improvement in results of the lecture for the character of fundamental elements and series-parallel circuit have to be presented in a way that is easy to follow and understand.

6. Conclusions

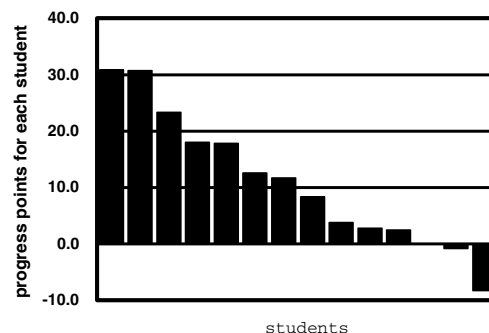In this paper, a new operating system independent E-Learning tool (iCASS) for education electric circuits

Table 1. Contents of iCASS

	theme of lecture	contents
1	sinusoidal waves	instantaneous value, phasor, amplitude, phase, frequency etc., reactance
2	character of fundamental elements	Ohm's law, phase difference between a voltage and a current, reactance
3	R-L-C circuits	shunt / voltage divide circuits, impedance, vector locus
4	resonance	resonance frequency, quality factor, resonance curve
5	A.C. power	instantaneous / effective / reactive power, power factor, complex power

Table 2. A result of the questionnaire

question	average points
interest degree for the electrical circuits	3.8
understanding level for the electrical circuits	4.0

and system was proposed. iCASS consists of Java applets which are embedded in HTML text. Therefore, adding the applets to traditional teaching might motivate students and allow to speed up the leaning process. That was clarified by use to teach actually.

The E-Leaning tool as presented at the conference can be found at http://www.sia.co.jp/~icass/index.html [6]. The tool is still under development and web page is continuously update.

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