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Development of a Human-like e-Learning System for Students' Active Learning

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ABSTRACT

There are two types of e-Learning systems, namely, a synchronous type system and an asynchronous type system. A Synchronous type e-Learning system uses TV conference systems and it gives students a sense of reality. An asynchronous e-Learning system has merits which are free from time and place. An important element of an asynchronous e-Learning system is WBT (Web Based Training) which is used in training in companies.

Interactive communications with a teacher are important for education. However, an asynchronous, lecture type e-Learning system has some difficulty for keeping students' motivation and encouraging active learning.

In this paper, we introduce a human-like e-Learning system which provides experiment contents for active learning and which have communicative functions, such as chat.

Keywords: e-Learning, Edutainment, Automatic Answering System, Human-like System

1. Problems of Existing e-Learning systems

E-Learning systems are spreading over companies and universities rapidly. Synchronous type systems which use TV conference systems has a sense of reality and interactivity with the teacher. But this system has the demerit of limitation of time and place.

On the other hand, an asynchronous e-Learning system has no limitation on time and place. Students are able to have a lecture anytime or everywhere. However, there is no interaction with the teacher. The student hears lecture and there is no active

learning components. Many existing asynchronous e-Learning systems manage only students' learning progress through the internet.

Therefore we suggest a human-like e-Learning system which has the ability to teach according to students' learning situation. Students are able to learn actively through experiments (Fig. 1).

Students access the learning site, where they learn the contents which include a page that lets student be active (through experiment and trial-and-error). The system watches the students' activity, and then the system judges the students' situation. Further contents are served based on the judgement of the system (Fig. 2).

This system serves contents according to each student. This is similar to a role-playing game. It is important for the e-Learning system to serve the contents that matches situation of each student.

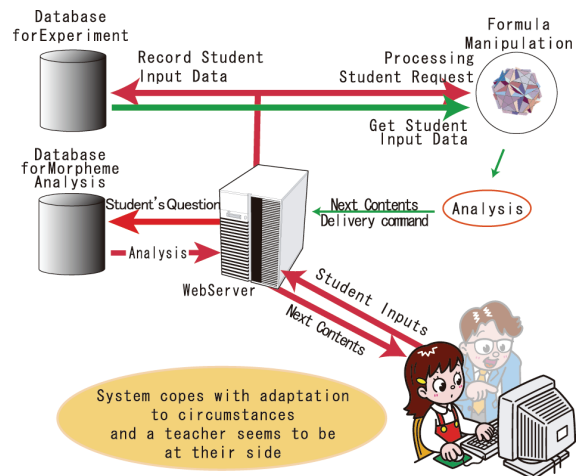


Fig. 1 System Image

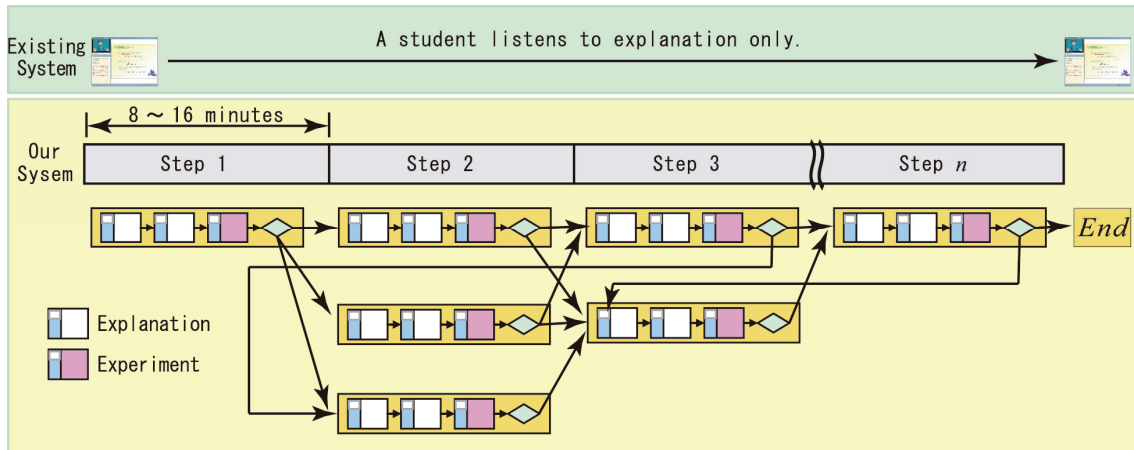


Fig. 2 Contents Control

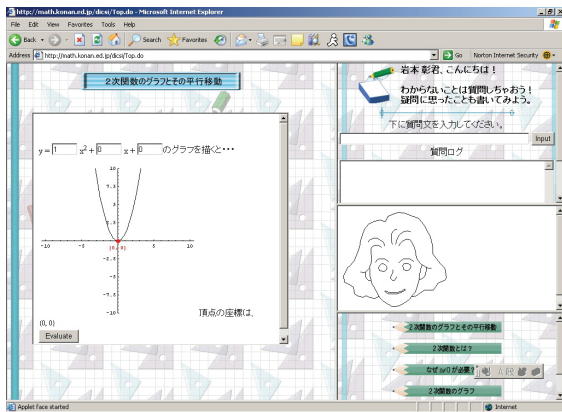


Fig. 3 Contents Image

Table 1 Experiment Patterns

Pattern	Judgment
1, 0, 0	The student notes parameter a .
0, 1, 0	The student notes parameter b .
0, 0, 1	The student notes parameter c .
1, 1, 1	The student notes nothing.
0, 0, 0	The student could not operate.

	Student's Input	Generate Pattern
1st	$y = \boxed{1}x^2 + \boxed{2}x + \boxed{3}$	Change a b c 1st → 2nd 1 0 0
2nd	$y = \boxed{2}x^2 + \boxed{2}x + \boxed{3}$	2nd → 3rd 0 1 1
3rd	$y = \boxed{2}x^2 + \boxed{3}x + \boxed{4}$	3rd → 4th 1 1 1
4th	$y = \boxed{1}x^2 + \boxed{2}x + \boxed{3}$	4th → 5th 0 1 1
5th	$y = \boxed{1}x^2 + \boxed{0}x + \boxed{0}$	Pattern 1 1 1

Fig. 4 Patterning of a Student's Experiment Data

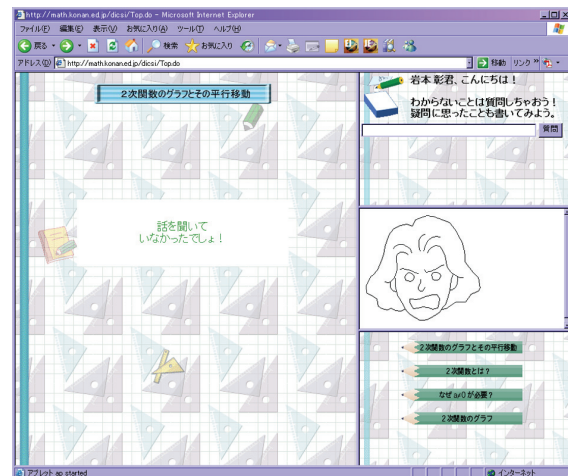


Fig. 5 The screen that the system scolds the student

2. How to get Student's Situation

We made the contents of high school mathematics syllabus unit "Quadratics and their graphs". The contents are a lecture and some experiments of drawing graphs. In addition, the system observes input data of students and chooses appropriate instruction contents according to

students' situation. (Fig. 3)

For making teaching contents according to students' situation, we patternize student's input data. For example, a student have experiments of drawing " $y = ax^2 + bx + c$ " graphs. Fig. 4 is an example of patterning of student's experimental input data. The

system judges ‘All parameter changed’ (Table 1). By this patterning, the system provides the next suitable content for the student.

Furthermore, we added the function to give negative feedback to the student who did not listen to our lecture (Fig. 5). Usually, teacher scolds a student who does not listen to the lecture in real class. So it is a necessary function for the system.

3. How to Communicate with Students

3.1. Automatic Answer

In our classes, we are able to answer students’ question. However, it is difficult to answer questions immediately in an e-Learning system without answer models.

Therefore we prepared some template questions as follows.

1. How does a graph change when the parameter a is changed?
2. How does a graph move when I change parameter b ?
3. How does a graph move when I change parameter c ?
4. Please teach me relation between the y -intercept and parameter a, b, c .
5. What is the relation between apex and parameter a, b, c ?
6. How can I get the coordinate of apex of parabola?
7. Is the graph of quadratic function symmetrical?
8. Please tell me how to do right-left parallel translation of the graph?
9. Please tell me how to do up-down parallel translation of the graph?
10. Can you draw the graph of an side opened parabola?

A student inputs the questions (Fig. 6); the system chooses the most similar question from template (Fig. 7).

However, the judgment of the system is not always the same to the questions of the student. If the system displays a wrong answer, the student clicks the "No" button. And the system enumerates a different question (Fig. 8).

3.2. Morpheme analysis

It is necessary for the system to understand students’ question correctly. It is difficult for a computer to classify Japanese sentences into words. In Japanese, a sentence does not include spaces to distribute characters. So we use the morphological analysis system ‘Sen’.

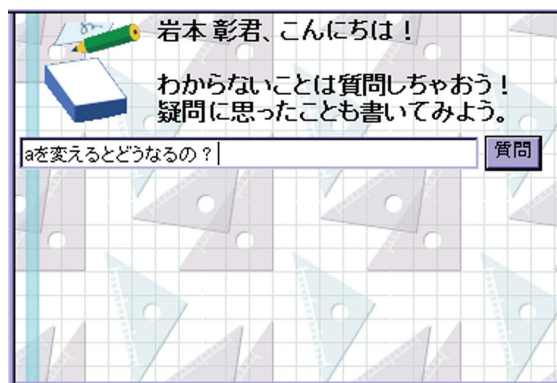


Fig. 6 Input Questions

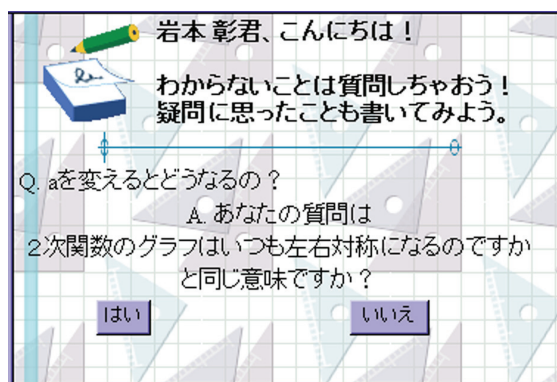


Fig. 7 Compare with Template Question

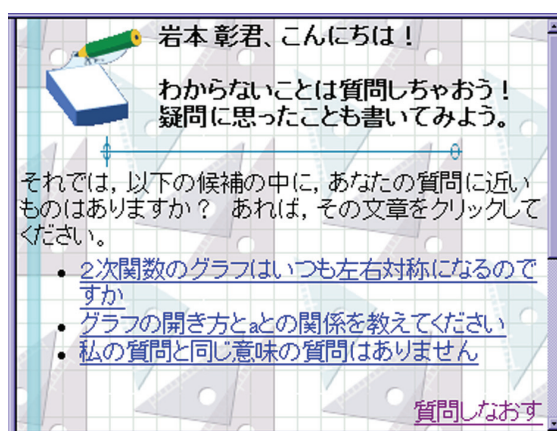


Fig. 8 Enumerate other Template Question

The template questions and students’ question are separated by Sen into indexing words. The system computes the precision by using these words lists. For example, a student asks the system “ a の値を変化させるとどうなりますか? (How does a graph change when the parameter a is changed?)”. The system gets primitive words list by the morpheme analysis ‘Sen’ (Table 2). The system uses necessary word class and measures distance of the student’s question and template questions.

Table 2 Morpheme analysis

Question : a の値を変化させるとどうなりますか？		
Word	Primitive	word class
a	a	未知語 (Unknown word)
の	の	助詞-連体化 (Particle)
値	値	名詞-一般 (Noun)
を	を	助詞-格助詞-一般 (Particle)
変化	変化	名詞-サ変接続 (Noun)
さ	する	動詞-自立 (Verb)
せる	せる	動詞-接尾 (Verb)
と	と	助詞-接続助詞 (Particle)
どう	どう	副詞-助詞類接続 (Adverb)
なり	なる	動詞-自立 (Verb)
ます	ます	助動詞 (Auxiliary verb)
か	か	助詞-副助詞 (Particle)
？	？	記号-一般 (Symbol)

3.3. Vectorization of question word

Let T_i ($i=1, 2, 3, \dots, n$) denote template questions. Then we get the word list (WT_i) of T_i . And let S_j ($j=1, 2, 3, \dots, N$) denote students' questions. Then we get the word list (WS_j) of T_i . For example,

T_1 : “ a の値を変化させるとグラフはどのように変化しますか？ ”
(How does a graph change when the parameter a is changed ?)

$WT_1 = \{a, \text{値}, \text{変化}, \text{する}, \text{グラフ}\}$
($WT_1 = \{a, \text{value}, \text{change}, \text{do}, \text{graph}\}$)

S_1 : “ a の変化させるとグラフはどのようになりますか？ ”

$WS_1 = \{a, \text{変化}, \text{する}, \text{グラフ}, \text{なる}\}$

We introduce the following notations:

- w_i : The word of question W
- m : Number of w
- n : Number of template questions
- N : Number of student question of the past
- $f_{i,j}$: Frequency of w_i in the question
- n_i : Number of questions which includes w_i

$$W = \left\{ \bigcup_{i=1}^n WT_i \right\} \cup \left\{ \bigcup_{j=1}^N WS_j \right\}$$

$$m = |W|$$

We define the question term vector as follows. $l_{i,j}$ is Logarithmic TF(Term Frequency) weight. g_i is probabilistic IDF (Inverse Document Frequency) weight.

$$s$$
 : Term vector of student question
$$s = (l_{0,1}g_1, l_{0,2}g_2, \dots, l_{0,m}g_m)$$

q_j : Term vector of template question

$$q_j = (l_{j,1}g_1, l_{j,2}g_2, \dots, l_{j,m}g_m)$$

$$(j = 1, 2, \dots, n)$$

$$l_{i,j} = \log(1 + f_{i,j}) \quad (i = 1, 2, \dots, m)$$

$$g_i = \log \frac{n - n_i}{n_i}$$

We compute the similarity between student's question and templates by cosine measure.

s : Term vector of student's question

q_j : Term vector of template question

$$\cos \theta = \frac{s \cdot q_j}{\|s\| \|q_j\|}$$

The system selects the template question which has the maximal cosine measure.

3.4. Improvement of automatic answer

TF-IDF is often used in text mining. However, a student's question is too short to identify the template questions. Therefore we updated weight whenever a student asked the system a question.

For example, a term frequency of student question is

$$(f_{0,1}, f_{0,2}, \dots, f_{0,m})$$

and a term frequency of selected template question is

$$(f_{j,1}, f_{j,2}, \dots, f_{j,m})$$

We update weight as follows.

$$f_{j,i} = f_{j,i} + f_{0,i}$$

In this way we are able to improve value of cosine measure by updating f_{ij} . (Table 3)

Table 3 Average of cosine measure answering correctly

	No update	1 update	2update
Average of cosine measure	0.53	0.69	0.77

4. Entertainment in Education

4.1. Automatic drawing of facial expression

Edutainment is a word which combines education and entertainment. It is desirable for e-Learning systems to have a function of entertainment. Otherwise students do not stay interested in the contents.

So, we created several characters of teachers. A student is able to choose from these teachers. But it is troublesome for us to make animation for each character.

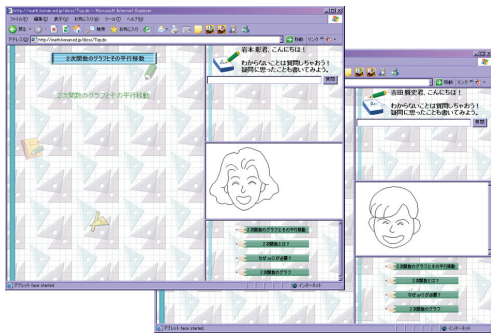


Fig. 9 Teacher characters

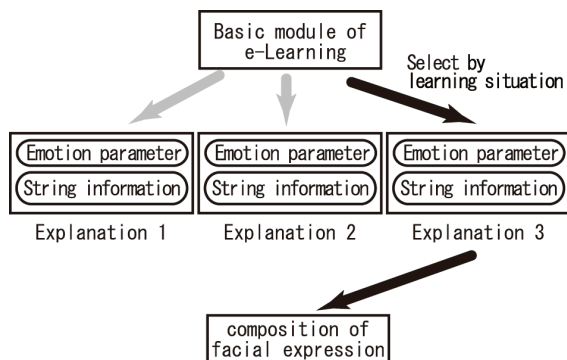


Fig.10 Automatic drawing of facial expression

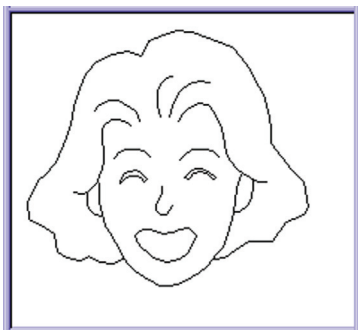


Fig. 11 Normal facial expression



Fig.12 Angry facial expression

Therefore we programmed an automatic drawing system using the voice data and these vowel data (Fig.10). We can reduce time required to make the contents by this function. Moreover, it is possible to change the character's facial expressions according to the contents (Fig.11, Fig.12). Emotion parameters are happiness, sadness and anger. String information is vowel (Japanese hiragana) data and the timing data.

4.2. Data for facial drawing

Facial drawing data consists of five items.

1. Index
2. Audio file name
3. Length of audio play time (sec)
4. Japanese hiragana character data
5. Rate for a sentence of character
(Short: 1 <---> 5 <---> 9 :Long)

For example, two sentences are included in a Web page. The data file is as follows.

```

0
./wave/0_1.wav
5.38
にじかんすうのぐらふと、そのへいこういど
うについてべんきょうしましょう
555555 5 555 5 9 55 5555 555 5 558 55555
55555

1
./wave/0_2.wav
7.43
とくによこほうこう、えつくすじくほうこう
のへいこういどうについてかんがえてみま
しょう
559 555559 8 555555 5555 5 5555555 5 555
55555 55555
  
```

We comment on a calculation way of play time of character. A value r_i is relative time length of voice of vowel. of character. T is length of audio play time. A character play time t_i is computed as follows (Table 4).

$$R = \sum_{i=1}^n r_i$$

$$t_i = \frac{r_i T}{R}$$

The shape of a mouth of a vowel keeps for t_i second. In this way we use audio data and vowel sound synchronization file, and the system generates real time animation.

Table 4 Compute of vowel plays time

4th Item		vowel	5th Item	Play Time
に	N i	i	r_1	t_1
じ	J i	i	r_2	t_2
か	K a	a	r_3	t_3
ん	N n	n	r_4	t_4
す	S u	u	r_5	t_5
う	u	u	r_6	t_6
⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮
ま	M a	a	r_{n-2}	t_{n-2}
しよ	Sh o	o	r_{n-1}	t_{n-1}
う	u	u	r_n	t_n
Total			R	T

4.3. Merit of automatic drawing system

The automatic facial expression real time drawing system reduced our task a lot. The teacher only prepares the audio data for each explanation.

Usually, animated images are time consuming. Synchronizing the mouth drawing and the voice is complex. Besides, it is difficult for us to modify animation.

In addition, there is a system using video capture. In the case of video capture system, the teacher needs skill to edit the movie.

The automatic facial expression real-time drawing system is useful because it does not need special skill for making the contents.

5. Conclusions and Future Study Directions

The developed question and answer system cannot reply to questions which do not include the template question. In this case, the present system sends an e-mail to the teacher. We have to devise an answering system which can answer every student's question, and does not require e-mail.

On the other hand, we are able to modify the contents easily using character real-time drawing. But the system requires the contents scenario and speaker's tone data. A problem under consideration is automatic data generation from a voice.

However, we are able to make the educational contents without video capture system or any special skills. These are important things for creating educational content.

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