38

CAI SYSTEM WITH MULTI-MEDIA TEXT THROUGH WEB BROWSER FOR NC LATHE PROGRAMMING

Yoshio Mizugaki[1], Koichi Kikkawa[1], Masahiko Mizui[2], and Keisuke Kamijo[2]
[1]*Dept. of Mechanical And Control Eng., Kyushu Institute of Technology, Japan*
[2]*Dept. of Mechanical Eng., Kyushu Kyoritsu Univ., Japan*
e-mail: mizugaki@mech.kyutech.ac.jp

Abstract: A new Computer Aided Instruction (CAI) system for NC lathe programming has been developed with use of multi-media texts including movies, animations, pictures, sound and texts through Web browser. Although many CAI systems developed previously for NC programming consist of text-based instructions, it is difficult for beginners to learn NC programming with use of them. In the developed CAI system, multi-media texts are adopted for the help of users' understanding, and it is available through Web browser anytime and anywhere. Also the error log is automatically recorded for the future references. According to the NC programming coded by a user, the movement of the NC lathe is animated and shown in the monitor screen in front of the user. If its movement causes the collision between a cutting tool and the lathe, some sound and the caution remark are generated. If the user makes mistakes some times at a certain stage in learning NC, the corresponding suggestion is shown in the form of movies, animations, and so forth. By using the multi-media texts, users' attention is kept concentrated during a training course. In this paper, the configuration of the CAI system is explained and the actual procedures for users to learn the NC programming are also explained too. Some beginners tested this CAI system and their results are illustrated and discussed from the viewpoint of the efficiency and usefulness of this CAI system. A brief conclusion is also mentioned.

Key words: CAI, NC lathe programming, multi-media, Web browser, CMI

1. INTRODUCTION

NC (Numerical Control) programming is the basic and fundamental technology in manufacturing. NC lathes are the most popular machine tool and widely used in actual machining processes. Its programming seems to be easier than that of 3-axis or higher order machine tools, but it is still difficult for beginners to learn it by oneself. The reason is that it needs the spatial perception on the collision avoidance between a cutter and a work. So CAI (Computer Aided Instruction) systems on NC lathe programming have been strongly requested especially in industries. The objective of this study is to develop a user-friendly CAI system for NC lathe programming in the Internet era.

2. DEVELOPMENT OF CAI SYSTEM

2.1 NC lathe programming and procedures of CAI development

Fig. 1 shows the specimen of the exercise in the CAI system developed. As easily understood, the NC lathe programming requires not only the geometric aspect including the avoidance of collision, the calibration of the position of cutting edge and so forth, but also the information of machining conditions such as the cutting speed, the feed per revolution, the depth of cut and so forth. The specimen needs the operations of normal turning, tapping, grooving, chamfering and so forth. Therefore its programming should be written with some fundamental NC codes such as G, F, M functions as shown in Fig. 2.

The CAI system has been developed in the procedures shown in Fig. 3. The procedures consist of three stages. The first is about making of the CAI text based on the education theory. The second is about the determination of the CAI system configuration based on the CAI theory. The third is about the coding of the CAI system and its uploading in the Web site based on the computer theory. In the below, the main two stages are explained according to the actual procedure of the development.

2.2 Content of CAI text

In the first stage of CAI system development, the content of NC programming training course held in 2000 through 2001 were surveyed through Web search engines that were google, excite and lycos. The keywords of search were "NC, lathe and training course." As the result, ten

case studies were collected. Considering the contents collected and surveyed, the following text contents were adopted in the CAI system developed.

1. General guidance of NC lathe
   Fundamental configuration of NC lathe, Features of turning, Automatic Tool Changer, Coding process of NC programming.

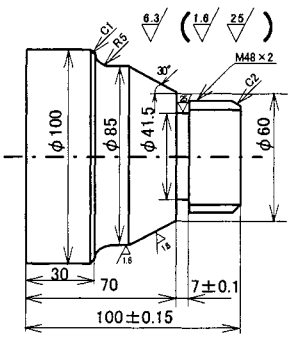

Figure 1. Specimen of work
For NC lathe programming.

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O0001 ;
N1 ;
G50 S2000 ;
G00 T0202 ;
G96 S100 M03 ;
    X54.0 Z10.0 M08 ;
          Z0.0 ;
G01 X24.0 F0.25 ;
G00 X46.0 Z1.0 ;
G01 X50.0 Z-1.0 F0.2 ;
          Z-25.0 ;
G00 X52.0 Z10.0 ;
    X200.0 Z150.0 ;
    T0200 ;
M01 ;
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N2 ;
G00 T0303 ;
G97 S1300 M03 ;
    X29.0 Z10.0 ;
          Z1.0 ;
G01 X25.0 Z-1.0 F0.2 ;
          Z-41.0 ;
G00 X24.0 Z10.0 ;
    X200.0 Z150.0 M09 ;
    T0300 M05 ;
M30 ;
```

EOB
End Of Block

G01 X50.0 Z-1.0 F0.2 ;
word word word word
Block

Figure 2. Sample codes of NC programming.

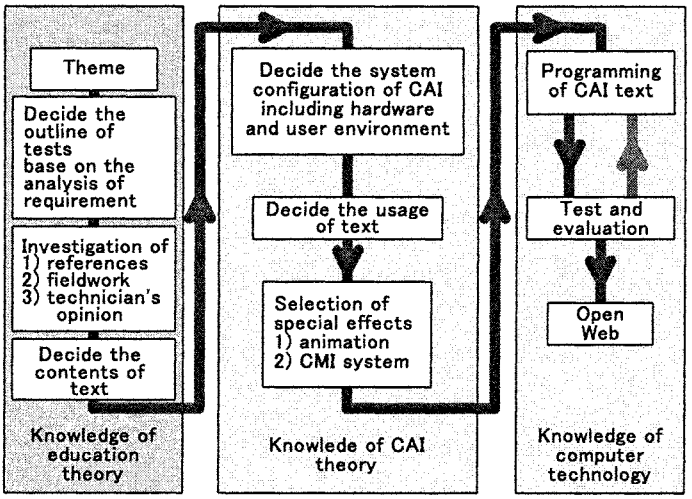

Figure 3. Procedures for the development of the CAI system.

2. Fundamental terms of NC lathe programming
   Coordinate systems of machine tool and workpiece, zero offset, absolute and incremental programming, absolute and incremental dimension, etc.
3. NC programming
   Program start, end of program, Block; word; address; character, Sequence number, dimension word (X, Y, Z, U, V, W, P, Q, R, A, B, C, D, E), F , G, S, T and M function words.
4. Instruction code of G, S, F and T function series
   Rapid traverse, linear interpolation; constant surface speed control; feed rate, override, ATC tool registration

The above content is equivalent to the content of ordinary NC training course in 2 to 3 hours. The CAI system was designed so that a trainee could finish and master the above content generally within one and a half hours.

2.3 Configuration of CAI system and its feature

In the second stage, the requirements for the CAI system are below.

1. Trainees as users of the CAI system are university students of the department of Mechanical Engineering.
2. The expected goal is that trainees understand the outline of NC lathe programming and have the experience of generating NC programs through a simple exercise.
3. All operation in the CAI system can be executed through a Web browser.
4. The number of trainees is 6 to 8 persons per class.
5. The time for CAI training is expected 90 minutes.

Fig. 4 illustrates the hardware configuration of the CAI system with using PCs for CAD/CAM facilities in a classroom of Kyushu Kyoritsu University. (The specification of CPU is Pentium III, 667 MHz, 128 MB of memory with a 17" monitor.)

The fundamental policy of giving suggestions in this study is the tutorial type in the CAI system category. In this tutorial type, a proper suggestion is shown in another window of Web browser when a trainee requests a suggestion by oneself and/or makes a mistake in answering a question. Usually the questions are displayed with a drawing of the specimen and the answer columns follow, as shown in Fig. 5.

The button for the request of suggestion is prepared as shown in Fig. 6. In this suggestion, some visual assistance including drawing, animation and video would be shown too. When the tool path was programmed and answered by the trainee, its motion would be displayed as the animation in the window. At the same time, the collision detection between the cutter and

the workpiece would be carried out as the 2-dimensional simulation and the occurred collision would be animated with using the software of FLASH 5 developed by Micromedia Co. (See Fig. 7.) In the context of the CAI system, the various animations are prepared and embedded in 17 scenes totally.

One of significant features of the CAI system developed is that this system can be accessed from anywhere and anytime through a Web browser. This feature offers many advantages for trainees as mentioned below.

1. A trainee can learn and master the subject according to his/her own speed of understanding.
2. A trainee can learn the subject whenever and at any number of times he/she wants.
3. Visual and sound aids with the multi-media text can encourage the attentiveness and concentration of a trainee and the efficiency of his/her learning.
4. The quick response of the CAI system offers the interactive and real-time effects in giving marks of questions.
5. The self-learning mechanism is supported based on the Computer Managed Instruction (CMI) system and automatically the proper CAI text would be shown to a trainee due to the state of learning.

The CMI system deals with the following three parts. The first one is to manage the trainees' records. The second one is to mark the answer of trainees. The third one is to analyze the trainees' records and their state of answer. Based on the analysis of the trainee's state, proper suggestions would be presented or shown in another window. Fig. 8 shows the total configuration of the CAI system developed. This CAI system has been improved through the trainee's execution.

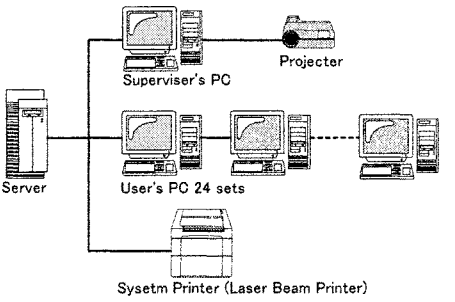

Figure 4. Hardware network in a classroom equipped with the CAI system.

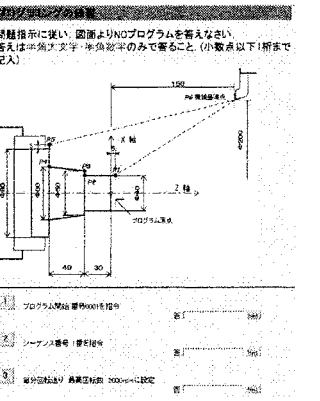

Figure 5. Sample of exercise system in the CAI.

3. EXPERIMENTS

3.1 Outline of experiments

In order to evaluate the accomplishment of the CAI system developed, the comparative experiments had been done. Four different texts of NC lathe programming were handed to four groups of students respectively. Then the result of learning in each group was compared with each other. Each group consists of three students and total twelve students were cooperated. Every student joins only one group. The four different texts and assistance to each group are listed below.

A: The text is the multi-media text provided in the CAI system. The organized assistance by a teacher has been applied progressively when a student faces to some difficulty in solving a question. Before starting the CAI experiment, the additional explanation how to use the CAI system was delivered to students for five minutes. Five minutes are excluded in the total time of experiment.

B: A printed text including the same content of the multi-media text in the CAI system has been used. The organized assistance by a teacher has been done only based on the request of a student.

C: The text is the multi-media text provided in the CAI system as well as in A. There is no additional explanation for students how to use the CAI system. The organized assistance by a teacher has been done only based on the request of a student.

D: The text is the revised multi-media text for the revised CAI system. The revised CAI system has been improved according to the feedback information of students. No organized assistance by a teacher.

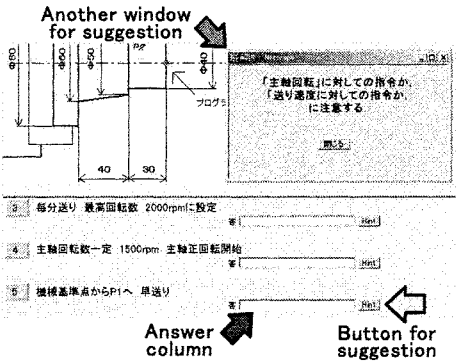

Figure 6. Helpful suggestion in another Window.

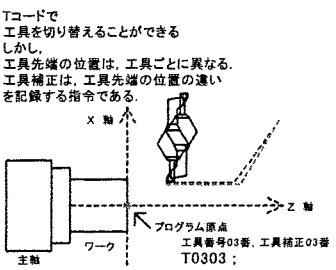

Figure 7. Advised suggestion for the trainee based on one's request or error.

The results of the exercise by the four groups have been compared with each other and summarized in Fig. 9 (a) and (b). The exercise consists of 13

questions. Students reply a question to get the right answer, and then proceed the next question. Fig. 9 (b) summarizes the time required from the start of self-learning to the end of self-learning.

3.2 Results

The CAI system seems to be more useful and helpful compared with the printed text as shown in Fig. 9(a). The result of Group B shows that the printed text is unsuitable for beginners to master the NC programming.

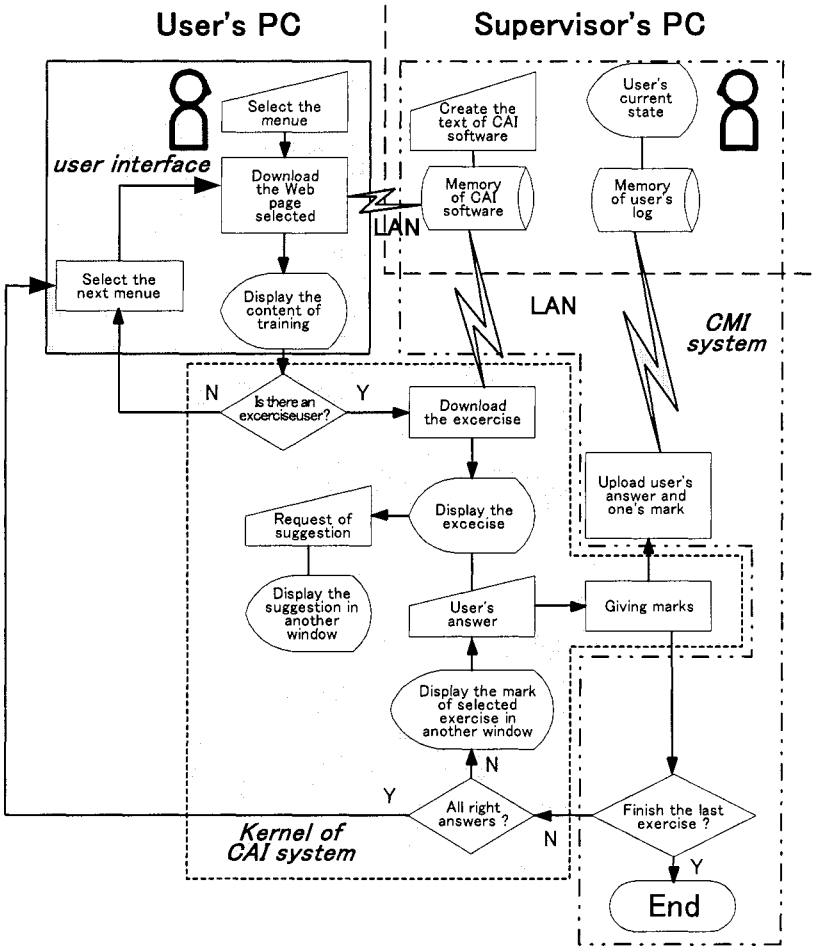

Figure 8. The schematic configuration of the CAI system.

After the interview to the members of Group B, it was found that they skipped the important explanation of NC programming in the printed text.

The printed text has a few educational effects in the latter trial except the first trial. Fig. 9 (b) shows that the combination of CAI system and organized assistance is very useful in learning. It suggests that the organized assistance had better be embedded as the improvement of the CAI system in future.

4. CONCLUSION

In order to give a CAI system the independence on the locality and on the time-restriction, the web-based multi-media-assisted CAI system has been developed. Through its development and the comparative experiments with other learning texts, its usefulness has been verified. Especially trainees could keep attention during the training. The CAI system is essential and very promising in the learning of NC programming. The well-organized assistance should be investigated deeply and embedded in it as the kernel of the machine intelligence. It is the further study the future CAI system.

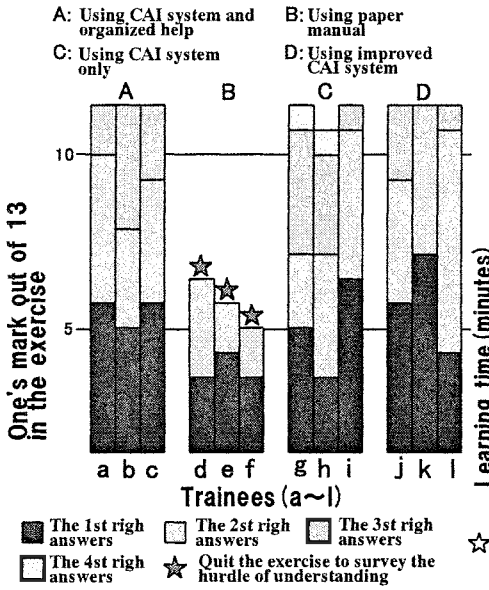

Figure 9(a) Experimental results on the trainees' marks.

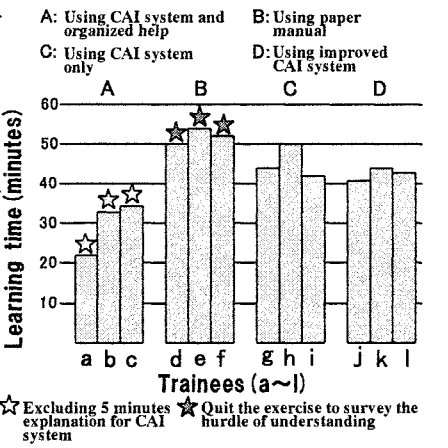

Figure 9(b) Experimental results of trainees based on categories of used texts.

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