The CNC turning virtual as teaching and training aid of CNC programming

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Abstract: *The study is aimed at (1) describing how the building process of a virtual reality CNC can perceive input and react as a real CNC machine, and (2) showing the results of of the real CNC machine as used as a programming learning media. The study involved 16 students of the Faculty of Engineering as the research subjects. Data collection method was conducted in a span of four months of effective face-to-face class activities. Data collection took place in the CNC lab of the Faculty of Engineering, UNY. Results of the study show (1) the students are interested and excited to use the virtual CNC which provides a visual effect of environment of CNC machine in the monitor, actively trying the simulation of numpad virtual in the monitor, inputting data on the panel virtual, and making simulation or execution of the CNC program at CNC Machine Simulator, (2) the students practice to make and execute the CNC programming individually in the classroom or outdoor class. And (3) CNC Virtual can be used as teaching and training media classically (in classroom), individually learning, even E-learning.*

Keywords*: CNC-simulator, teaching-aid, CNC programming*

1. Introduction

The National Education Ministry has decided that education development must concern with three sectors, one of them being relevance and competitive education quality improvement. The improvement of relevance and competitive education quality is done by addapting the curriculum of education to the needs of people which are dynamically developing. That addaptation must exist in the form of teaching, guiding, and training.

One of the sectors which develops fast, especially in the industries, is the system of production-process automation. Nowadays, almost all of industries are expanding production-process automation and replacing manufacturer tools which are used with machines with tools which can be controlled automatically for supporting automation.

For improving the relevance and competitive education quality, this automation system is included into the curriculum, especially in the machine engineering education curriculum, starting from the Machine Production Department in the vocational school to the Machine Engineering Department in the university. However, including production automation system to the curriculum is not easy for many factors.

Indra Djati Sidi (2001 : 37) stated that, based on the some education researches, the teacher is one of the dominant factors which influences learners' success in transforming science and technology, and in internalizing morality and ethics. According to Winarno

Surakhmad (Pannen, dkk, 1999 : 6), holding education needs certain requirement. Besides professional teachers, it also needs cost and proper education infrastructure. If education is held without considering the requirements, there will be unfavourable condition which can cause the process not to be qualified and the learning goal not be achieved.

Improper infrastructure condition can be found in the field. The most is in the learning process of CNC automation, both in the universities and machine engineering department of Vocational School. CNC machine which is the main facility for forming competence of CNC operating and programming is less than the number of students, even many machine engineering departments do not have one.

The problem causes the learing process of CNC to be held in groups, in turns, when operating the machine. For machne engineering departments which do not have one, the process is held without a CNC machine. Those condition cause students not to have a chance to interact with the machine. Ultimately, the students do not have enough experience in operating the machine and the ability in making CNC programs cannot match the standards.

Quality improvement of CNC learning can be done by giving the students as much chance as possible to practise. However, to provide CNC machine as many as the student number in the class needs high cost and not every machine engineering department is capable of doing so. Therefore, to fulfil the need of CNC programing learning, virtual reality CNC needs to be developed.

Virtual reality CNC media is a computer program that, when it runs on the screen, will reproduce two-dimension images. The CNC machine is completed with operating buttons resembling the real CNC machine. Virtual operating buttons on the screen can have the functions as the real buttons on the real CNC machine. This media is the representation of the CNC machine functioning as (1) to simulate button functions on the control panel, (2) to simulate inputing CNC program (data input) as input data to the control system of CNC machine, and (3) to simulate CNC program execution as animation of machine process in the CNC machine.

The research problems of the present study are: (1) How is virtual reality development which can show the real environment visualization of a CNC machine on the computer screen?; and (2) How is the feasibility of the virtual reality as CNC programming learning media?

2. Method

The study was research and development (R & D). The objectives of the study was: (1) to explain the bulding process of a virtual reality CNC which can perceive input and can react as the real CNC machine, and (2) to show the the results of that virual reality CNC feasibility as CNC programming learning media.

The study involved 16 research participants who were students of the Faculty of Engineering. Data collection method was conducted in a span of four months of effective face-to-face class activities. Data collection took place in the CNC lab of the Faculty of Engineering, UNY.

The development of CNC virtual reality is done by using the CNC lathe machine training type EMCO, made by EMCO Maier Austria. CNC virtual reality is developped by using Visual Basic 6 software, with Windows XP Operating System. The result is a computer program which can present physical environment visualization of CNC machine on the computer screen. Physical environment of CNC machine which is displayed is control panel, monitor, and clamping of work-piecef on the machine.

3. Findings and Discussion

Technology improvement, especially computer, should also be used in learning media. The using of computer in learning especially as interaction media and learning application, they are drill and practise, simulation, discovery, tutorial, problem solving, and games.

Computer use in learning activity, at least, has three purposes, they are cognitive, psychomotor, and affective. For cognitive purpose, computer can teach the concepts, principle, steps, process, and complex calculation. Computer is also able to explain that concepts simply by using combination of animated audio and visual so it will be suitable for independent learning.

For psychomotor purpose, computer is also able to serve learning process which is presented in the form of games and simulation which are so good for creating work condition. Some examples are; simulation of aeroplane landing, simulation of war in the worst condition, etc. For affective purpose can be done when the program is designed well by giving sound or video clip which can be a trigger. Then, behaviour learning/affective can be done by using computer.

Generally, there are three kinds of simulation. One, interactive and physical simulation. Physical simulation refers more to the physical object simulation for replacing the real system. This physical object is often chosen for it is smaller or cheaper than real system or objects, as the flying simulator.

Two, computer simulation. Computer simulation is an effort to duplicate real situation in a computer, so the situation can be learned for watching how it works. By changing variable, possibility of prediction can be made about the behaviour of that system. Three, simulation in training. Simulation is often used in the civil and military training. This, generally, happens when the cost is high or it's too dangerous for allowing training participants to use real tools in the real world.

Simulation about real environment which is made by computer, and user can have interaction with the result which shows the content of reality environment is called virtual reality. Virtual reality is an human-computer interaction format where a real or imaginative environment is formulated and the users can be connected and run that world. In the most successful virtual environment, the users feel that they really exist in the simulated world and that their experiences in the virtual world is equivalent to what they experience in the real environment.

Virtual reality can be applied in many sectors. In the engineering and sientific research, virtual environment is used visually for identifying everything happens to the physical world that is in the observation. Training for work in the dangerous environment or with expensive tools is better done by using simulation. For example, pilot practises by using flying simulation. Virtual reality may let medicals for practising the procedure of new surgery to the imitation human.

One of the senses which is often used for getting information from the environment is seeing sense. Seeing sense is used more often than others in processing information. Many psychology researches show that there are more information can be understood when it's served in the visual form than in nonvisual form.

Training by using virtual reality can reduce the cost compared with common training. Need of expensive training tools in the real laboratory, or additional tools for training can be eliminated. The advantages of using virtual reality as training tools are; (1) reducing duration of the training in the real environment, (2) can hold a training in the very dangerous condition, (3) save more cost to the same training, (4) providing unlimited access to the expensive tools, (5) omit the cost for going to the training center,

(6) cost of repairing/replacing of expensive machines can be eliminated.

CNC (Computer Numerical Control) machine is a machine which of the operating process is controlled by CNC system, that is a control system which of the controlling is done by using command in the form of alpha-numeric-code. Set of commands in the alpha-numeric-code and used for controlling machine operation of a product is called CNC program.

As shown above, the development of the CNC virtual reality is done by using research and development method in reference to the development of CNC lathe machine training type made by EMCO Maier Austria. CNC virtual reality is developped by using Visual Basic 6 software, with Windows XP Operating System. The result is a computer program which can present physical environment visualization of CNC machine on the computer screen. Physical environment of CNC machine which is displayed is control panel, monitor, and clamping of work-piecef on the machine. Look at Figure 1.

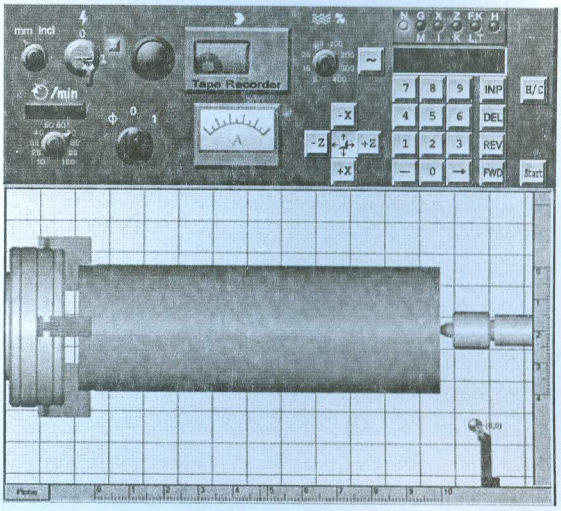
The view design of the control panel is made resembling to the control panel of the CNC machine TU-2A. This is aimed at the situation and feelings of the user as if they are in front of the real control panel of CNC machine TU-2A. Besides, they feel comfortable in using the machine and the sensation of the challenge as if they use the real machine.

Not all of the function of the visualized panels and buttons on the control panel can be simulated. Some are only images or accessories for giving sensation of reality and interative sensation. Switches and buttons whose functions can be shown by Figure 1.

Main switch, which can be simulated in two positions, those are "0" and "1" (OFF/ ON). The function of main switch is for turning the CNC machine on and off.

Main spindel switch, which can be simulated in three positions, those are "0",

Figure 1: Display of CNC Virtual Reality on the Monitor Screen



"1", and "CNC". The function of the switch is for turning the main spindel whether in the CNC operating function or in the manual operation function.

Manually operating button, that is button for moving the chisel on the X and Z axis manually.

CNC operating button, that is Numpad for writing the code and number (NC program) which is made on the computer screen and put in the memory, and buttons functioned in the program editing, which are DEL for deleting written character, REV for moving the crusor to the previous line, and FWD for moving the crusor to the next line.

Start button, for starting running the written program.

Animation window, in this part, animation of chiseling, which is constructed by some main components and supporting components. The main components are; (1) chuck, (2) workpiece, (3) live center, (4) and tool holder.

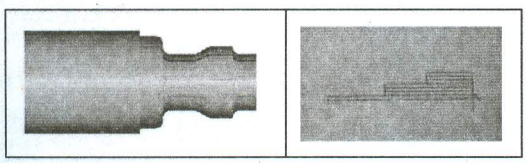
Typing buttons on the monitor screen (virtual buttons) are numeric buttons "0" to "9", "INP", "DEL", "REV", and "FWD", which can function to write the CNC program on the virtual monitor. It goes the

same as "START", and main switch ON/OFF, which can be operated identical to that button on the CNC machine. One of the excesses of the developped product is being able to save written CNC programs and recall saved programs for being activated and shown on the screen.

Besides, written CNC programs on the writing window of the CNC Program can also be run. A written program is the input which can be processed into an oupput. The response or the output of the given input is visualized as the run of CNC program reading by machine unit control. The run of CNC program can be observed by simulating the move of slicing tools on the animation window on the computer screen.

Response from the input which is command (code) of CNC programming can besimulated by using animation of relative lathe chiseling to the work stuff. CNC programming code which can be processed and animated are still limited, it is limited only for command code which is often used in the begining of making CNC program training for CNC machine TU-2A. Those command codes are: "G00", "G01", "G02", "G03", "G92", "M03", "M05", AND "M30". The animation result of the run of the CNC part program can be seen in the Figure 2.

Figure 2: The Animation Result of the Running the CNC Part Program



It can be stated that this study has been successful in developping CNC virtual software, that is a computer program which can present the visual effect of CNC machine TU-2A operating principle on the computer screen. The program can initiate, translate, and respond to each input well. Responses (outputs) as the result of initiation and translation from the input in the form of command codes in NC program, visually in not different from the respons which is done by the real CNC machine if the machine system control gets the same input.

Although in the product development, especially the view is successful, the development product has not been able to show the animation of program run for all command codes. Efforts for developping translation of CNC program to the animation have been able to be made though they are limited to some basic and simple codes, so the new products can be used for training basic CNC programming.

CNC virtual reality is able to fulfil the criteria as a learning media in two things: (1) the product is able to give the image and visual effect of operational function of CNC machine so it can be a media which can give experience to the users, and (2) the product is able to explain the concepts of learning materials so it can help the users in understanding learning materials.

Based on the product criteria as the media which visualize CNC machine, it can be stated that the product has a good view, especially the view format, matching shape and colour, and the suitability to the control panel of the real machine. Besides, the product is easy to be used/operated, and be able to build interaction between the users and the media. Therefore, the product can be a tool for making CNC program training, tool of direct interaction, and tool independent uses.

Based on the criteria as the media which can help explaining clearly the concepts of materials, it is known that the product whose materials are developed is able to explain clearly the concepts of materials, for the visualized materials have suitability to the learning materials of NC Machine, for example the materials about programming codes, and making NC programs. Besides the suitability of taught materials, there is also suitability between the chisel-moving animation done by the product to the real chisel

moving in the CNC machine. This causes users to find it easier to understand materials of programming concepts, for the concepts can be directly visualized by using animation on the developped product.

4. Conclusion

CNC Simulator with Virtual CNC can show the physical environment visualization of CNC turning machine. The control panel completed by accessories and operating buttons, clamping system of work stuff, lathe chisel, operation function simulation, and the animation of machine process from the executed NC program are able to generate students individually and actively in making CNC part programs and running that CNC part program on CNC virtual and CNC machine simulator whether inside or outside the classroom.

For being used as a teaching aid of CNC programming, CNC simulator which is developed has completed the requirements as education media with the following criteria: (1) The program has view quality, navigation, and operating, and being able to stimulate users to keep interacting with CNC virtuals, (2) The contens of the CNC Simulator with virtual CNC are good, especially for the basic elementary of CNC programming. The quality of content of this media is able to show the simulation of tool-path as the result of the running of the CNC part program on the basic program codes, where the users are able to combine the program codes which are put in as well as where they want to see the results of the given input, and (3) The CNC simulator can be used as a teaching, learning, and training media of CNC programming in the class, individual, outside the classroom, or by *E*-learning.

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