PLC-Based Educational Robot Controller

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Abstract: In this paper, we propose a PLC-based educational robot controller. As a educational robot controller, it is better to provide a programming tool based on graphical language than textual language. Ladder Diagram (LD) and Function Block Diagram (FBD), the most commonly used languages in industrial Programmable Logic Controller (PLC), are graphical languages. And also their logics are simple even young student can understand. Nevertheless LD and FBD languages as a educational robot controller are still difficult to use for young student because of their structure and interface. If we improve structure and interface and use intuitive icons, then young student can use LD and FBD as educational robot controller. So here we propose an educational robot controller based on PLC LD/FBD with intuitive icons which student can use easily in Windows-based environment. We expect it will reduce our time and effort for developing educational robot controller because we start on PLC not at the bottom. And it will make workers to use PLC has better interface and symbols.

Keywords: Educational robot controller, PLC, LD, FBD.

1. INTRODUCTION

Educational robot takes big part in personal service robot field. Now in the developed countries such as America, England, Japan and France, they use educational robot in formal school education. Recently Asian countries such as Korea, Singapore, Malaysia, Indonesia, and China recognize that educational robot is important and take it to formal school education. So the part and the importance of educational robot in personal service robot field are increasing [1].

LEGO MINDSTROMS is well-known educational robot and has NXT software which enables user to program robot using graphic interface such as programming palette, block, configuration panel and wire. Fig. 1 depicts NXT software [2, 3]. As NXT software, for educational robot controller, it is more suitable to offer user visual based programming tool than text based because visual is more intuitive and easy to use than text [4].

Ladder Diagram (LD) and Function Block Diagram (FBD) languages which are most commonly used in Programmable Logic Controller (PLC) are graphical languages [5]. Our laboratory have developed PLC loader and programming circumstance using LD and FBD languages for several years. The recent one is pSET (POSAFE-Q Software Engineering Tool) and it provides C language-based function block which enables a user use C language as well as LD and FBD languages. So in this paper, we propose educational robot controller using PLC loader what we developed, pSET. This will enable user who is not familiar with text based programming to program easily.

This paper is organized as follows: Section II introduces PLC and pSET what our laboratory developed. Section III suggest PLC-based educational robot controller with intuitive icons, improved user interface and Robot Control C Library (RCCL) and Section IV makes conclusions.

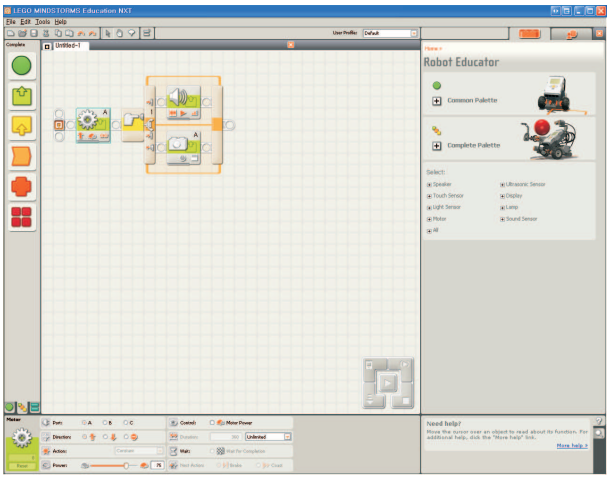

Fig. 1 NXT software user interface

2. PROGRAMMABLE LOGIC CONTROLLER AND PSET

Industrial PLC has LD and FBD languages defined in IEC (International Electrotechnical Commission) 1131-3. LD is most commonly used in PLC and is based on a technique used to design logic using relays and a concept of power flow between contacts which can control the operation of notional coils that represent variables. Fig. 2 depicts the main features of the LD language and its logic is equivalent to the following equation.

$$E = (A\ OR\ B)\ AND\ (NOT\ C)\ AND\ D$$

FBD is the first graphical language of the IEC languages and can be used to express the behavior of programs, functions and function blocks. The main features of the FBD language are shown in Fig. 3 which depicts part of a tank filling control. This controls FillValve, EmptyValve, and StirSpeed according to the value of inputs LOADEDWT, SW1, AVEWEIGHT and 2.5. As shown in Fig. 2 and Fig. 3, LD and FBD are graphical languages and they are also basic and mostly used languages in PLC. [5]

Our laboratory developed many versions of PLC loader for last 15 years. The recently one is pSET and it is an application programming tool of the POSAFE-Q which is a safety graded PLC developed for the reactor protect system of the nuclear power plant. Its graphic user interface and compile procedure are in Fig. 4 and Fig. 5. [6]

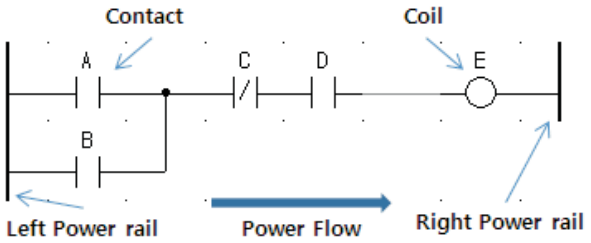

Fig. 2 Ladder Diagram concept

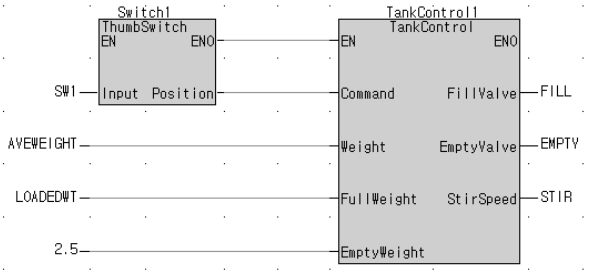

Fig. 3 Tank control Function Block Diagram example

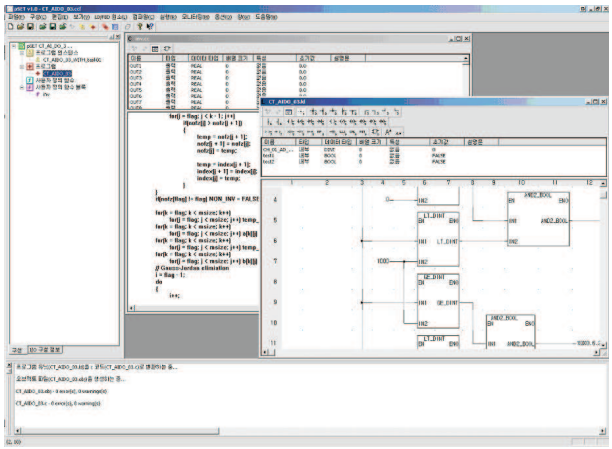

Fig. 4 Graphic user interface of pSET software

3. PLC BASED EDUCATIONAL ROBOT CONTROLLER

We propose PLC-based educational robot controller using pSET software which is programming tool of PLC because the logic of PLC is simple and we can use pSET software which is already developed in the process of developing. But the interface and graphical symbols of PLC are still difficult to young student to understand and to use because PLC was developed for grown-up workers in industry. So its visual needs to be improved so that young student can understand and use it easily. To improve visual, we need to develop intuitive icons which represent the functions of educational robot so that young student

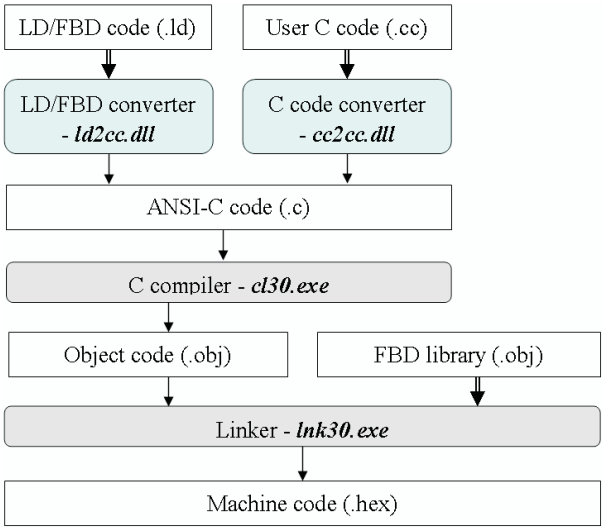

Fig. 5 Compile procedure of pSET software

can know what the icons mean at a look. Some examples of icons are in Fig. 6. User interface like menu, tool bar, work space, edit window and wire also need to be upgraded so that young students have interests. Fig. 7 depicts a simple implementation of PLC-based educational robot controller based on logic in Fig. 2 and using icons in Fig. 6. This program will conduct that if robot senses touch or light then turns LED on, turns LED off and rotates motor forward in order.

FBD pSET software provides C language-based function which enables a user import the algorithm written in C language used in field to pSET software. User can use this function by defining function block using C language as depicts in Fig. 8. By using this function user can program complex function using C language and use a program which is already written in C language without converting to PLC languages. To expand this function, we will combine RCCL with PLC-based educational robot controller. RCCL is a library of C routines for doing real-time control and graphic simulation of a number of industrial robots [7]. This will make PLC-based educational robot controller have more robot specific function like forward kinematics, inverse kinematics.

During developing PLC-based educational robot controller, not only above improvement but also simplification of pSET software is needed because PLC has many functions those are not necessary for educational robot controller and also has other languages like Sequential Function Chart (SFC) and Structure Text (ST). PLC and simplified PLC based educational robot controller concepts are in Fig. 9.

Fig. 6 Examples of intuitive icons

Fig. 7 Implementation of PLC based educational robot controller

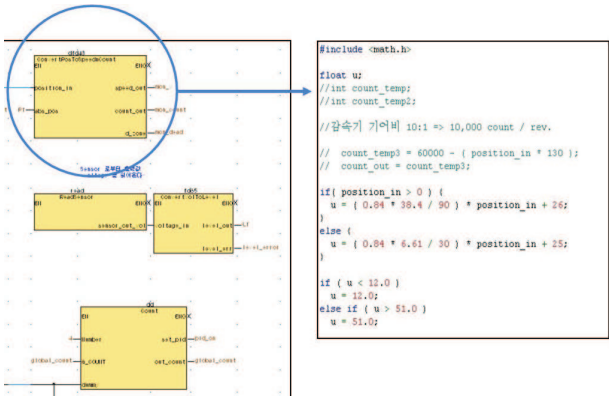

Fig. 8 Function block written in C language

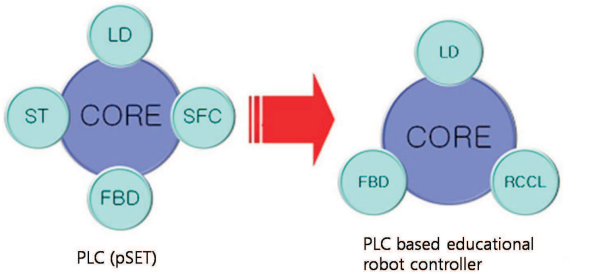

Fig. 9 Concepts of PLC and PLC based educational robot controller

4. CONCLUSIONS

LD and FBD, basic languages of PLC, are graphical languages and their logics are simple. These are fundamental elements for educational robot controller. And pSET has the function that can define function block in C language. But its visual is a little difficult to young students. So in this paper we proposed PLC based educational robot controller with RCCL and intuitive icons. By developing this we can reduce time and effort for developing educational robot controller by using PLC program which is already made. And young students will get experiences of industrial PLC by using PLC based educational robot controller, and these experiences will help the students apply their abilities to industry in the future. Also the other way around PLC based educational robot controller will affect industrial PLC to have better interface and be more intuitive.

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REFERENCES

[1] Ministry of Knowledge Economy, Republic of Korea, Minimalism Based User Created Robot Development, 2008.
[2] LEGO: http://www.lego.com/
[3] The NXT STEP Blog: http://www.thenxtstep.blogspot.com/
[4] ALCO: http://alcos.co.kr/
[5] R. W. Lewis, Programming industrial control systems using IEC 1131-3 Revised edition Analysis and Control of Web Tension Control System, The Institution of Electrical Engineers, 1998.
[6] Kyungmo Koo, Byungyong You, Tae-Wook Kim, Sengjae Cho, and Jin S. Lee, "Development of Application Programming Tool for Safety Grade PLC (POSAFE-Q)," 2006 spring conference of KNS
[7] Yoo Yeon KIM "RCCL based Robot Controller and Simulator", Pohang University of Science and Technology, Feb, 2008.