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PLC-Based Teaching of Electrical Automation Microcontroller

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Abstract: In the teaching of colleges and universities, due to the shortage of practical and experimental funds, the lack of equipment and the uneven level of teachers' practice, the teaching methods of many domestic colleges and universities follow the old fashioned way and are still stuck in the "theoretical explanation mainly supplemented by a small amount of practice backward stage. In this context, virtual simulation technology has gradually developed as a teaching demonstration method. The main purpose of this paper is to study the single chip teaching of electrical automation based on plc. In this paper, the basic projects of single-chip microcomputer application are simplified and integrated, and practical basic experimental projects are designed. The application methods of single-chip microcomputer in motor control, GSM communication control, field bus control and other fields are studied. The classification accuracy data experiments show that it is easy to conclude that the recognition accuracy of the optimized SVM in the training set and the test set is relatively better than that of the PNN algorithm, that is, the classification effect of the optimized SVM is better in solving the control chart pattern recognition.

1. Introduction

Each module of the experimental system of the single-chip microcomputer is independent of each other and can be connected in series to complete a complete project. The experimental implementation of each module can not only deepen the consolidation of the knowledge structure learned, but also appear to be completely independent. It will not cause the experiment to fail due to the failure of one of the links, and each module should be used step by step. To complete the experiment, you can complete the learning step by step, and perceive the real effect through various ways, so as to better improve the students' interest in learning [1-2].

In related research, Ayatinia et al. proposed a new iterative learning control (ILC) robust convergence condition for linear multivariable discrete-time systems with iterative variation uncertainty [3]. The method is based on Linear Matrix Inequality (LMI) and provides a fixed learning gain over time and iteration. Resende proposed a method to solve the team path tracking problem of mobile robots on the ground [4]. In this case, the proposal is a formation controller that handles three robots navigating coordinately (as a formation). Based on the proposed controller that guides the formation to follow a prescribed path, an extension to the path tracking case of a single ground mobile robot is also proposed.

This paper first analyzes the shortcomings of the annular production line system in teaching, introduces the development and application of single-chip microcomputers at the current stage, analyzes the shortcomings of most single-chip experimental systems based on the current teaching situation, and proposes the development of new ones suitable for colleges and universities. Design ideas of single-chip experimental system. The basic projects of single-chip microcomputer application are simplified and integrated, and practical basic experimental projects are designed. The application methods of single-chip microcomputer in the fields of motor control, GSM communication control and field bus control are studied. The experimental projects of the application of single-chip microcomputer in these aspects are designed, which provides a broad platform for students to master the application of single-chip microcomputer more widely.

2. Design and Research

2.1 Deficiencies of the System in Teaching Use

The automated production line system used for the processing of composite sets of products can be comprehensively used for installation and debugging training in the field of industrial control. In particular, programmable logic controller technology (PLC) is a required core professional course for all engineering majors, and the use of this production line for practical training accounts for a large proportion. In the process of teaching reform and professional construction, our school gradually realized that advanced industrial engineering ideas such as advanced manufacturing technology, modern logistics and supply chain management should be infiltrated into classroom teaching, and try to create an engineering experience environment for students as soon as possible after graduation. Adapt to the corporate philosophy and culture to lay a solid foundation. Through some problems and dilemmas found in the actual teaching of the system equipment [5-6], the summary is as follows:

(1) In the actual teaching process, although the system equipment can be very complete and comprehensive to carry out multiple functional training of PLC (mainly the control of industrial robots), but because the entire production line has relatively few workstations, it is impossible to achieve class Students use the same workstation to study the same training topic.

(2) Although the whole set of system equipment is divided into different training units, the purpose is to enable the trainees to start from the basic PLC control instruction training, and carry out training and learning from simple to complex, but in the actual teaching process Each training unit must rely on the entire production line, which will take up a lot of training space.

(3) In order to meet the learning needs of students from different majors as much as possible, and to facilitate students to carry out programming training at any time, three simulation laboratories have been established. However, because the laboratory simulation environment is different from the real production scene in the factory, the theory learned by the students Knowledge is disconnected from the reality of production. Simple simulation experiments cannot express the experimental process and results intuitively and vividly, making students feel that the knowledge they have learned is abstract and difficult to understand.

(4) Due to the late start of the major, there is still a big gap with some domestic brother colleges in terms of teaching facilities, teaching concepts, teachers, professional construction, etc. The knowledge learned by students is relatively outdated and lacks experiments. Internship equipment, it is difficult to have the opportunity to practice in the enterprise. Although students can use the annular production line as an experimental carrier to learn logistics management knowledge, when

there are about 1,000 students in the five majors in the school, it is clear that this annular production line system is far from meeting the teaching needs [7-8].

2.2 Principles of Development and Design of Single-Chip Microcomputer Teaching Experiment System

The development of the single-chip microcomputer teaching experiment system in technical colleges mainly follows the following principles:

(1) Based on the existing students' learning situation, according to the characteristics of students in the current technical colleges and universities, the experimental method can better guide students to study, and then master the basic design and application ideas of single-chip microcomputer.

(2) The modules of the experimental system are systematic, requiring strong operability and easy access. At the same time, it should also be suitable for the implementation of multiple experiments, whether it is an integrated implementation or a single project using a single module to complete the experiment.

(3) The implementation of each project can be supported by a complete experimental system, from the preliminary design of the project, program simulation, circuit drawing, circuit simulation, hardware effect function on the tester to the final students can weld according to the effect they want circuit and complete the experimental debugging.

(4) The selection of project content should focus on simplicity first, and the effect should be obvious, which can better arouse students' interest in learning. Then gradually increase the difficulty, and gradually build up the knowledge structure of students. For example, for the selection of the tester, it is necessary to realize the multi-red function as much as possible to meet the physical debugging of the experiment. The welding of the circuit should start from the basic circuit, and let the students have a step-by-step process of upgrading [9-10].

2.3 Overall Architecture

The general definition of automation system is based on the idea of modular design, with a single computer as the control basis, combined with peripheral functional units, showing its openness and comprehensiveness. The test system includes hardware and software. The device consists of a basic unit with a microcomputer chip as the core and an expansion unit that performs various test functions and connects with the I/O chip port to realize data communication [11-12]. A schematic diagram of the experimental setup is shown in Figure 1.

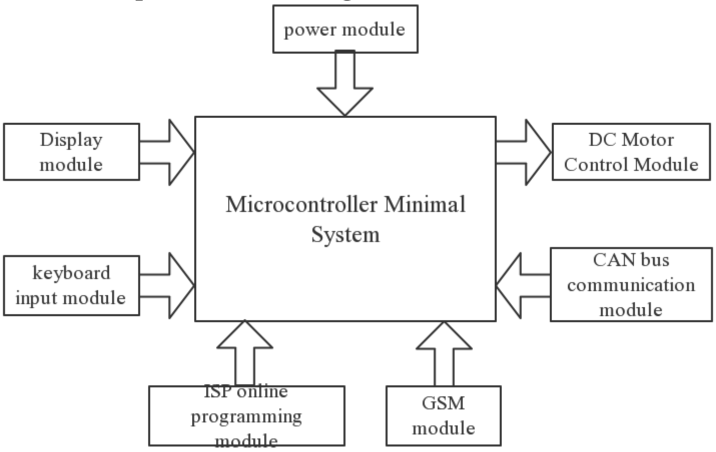

Figure 1: The block diagram of the integrated experimental system of the single-chip microcomputer

As can be seen from the figure, the hardware circuit unit of the unit test system mainly includes a minimum single-chip microcomputer system, a display unit, a keyboard input unit, a GSM unit, a motor control unit, a power supply unit and a programmer, and an electronic ISP. The minimum system of the single-chip microcomputer is the basic unit of the whole experimental system. It completes the operation of many experimental systems and processes a large amount of data; the motor control device is an important part of the two comprehensive experiments designed in this experiment. The system completes GSM communication and motor functions, PID control, etc.; the power supply unit provides constant DC power for the entire system.

2.4 Algorithm Research

As a kind of evolutionary algorithm, the basic principle of genetic algorithm is to imitate the "natural selection, survival of the fittest" in the law of natural evolution. In order to evaluate and judge the pros and cons of each individual, the absolute value of the error between the prediction function and the expected result is taken as the fitness value of the individual, as shown in formula (1). Compliance accounting conditions are met until the conditions of fitness evaluation are met. The specific selection is shown in equations (2) and (3), the crossover is shown in equations (4) and (5), and the variation is shown in equation (6).

$$F = k\left(\sum_{i=1}^{n} abs(y_i - o_i)\right) \tag{1}$$

Where k is a constant, n is the number of output nodes, yi is the expected output, and oi is the predicted output.

$$f_i = k / F_i \tag{2}$$

$$p_i = \frac{f_i}{\sum_{j=1}^{N} f} \tag{3}$$

In the formula, Fi is the fitness value, and N is the population number.

$$a_{kj} = a_{kj}(1-b) + a_{lj}b \tag{4}$$

$$a_{lj} = a_{lj}(1-b) + a_{kj}b \tag{5}$$

Where b is a random number between [0,1].

$$a_{lj} = \begin{cases} a_{ij} + (a_{ij} - a_{\max}) * f(g), (r > 0.5) \\ a_{ij} + (a_{\min} - a_{ij}) * f(g), (r \le 0.5) \end{cases} \tag{6}$$

Where amax is the upper bound of aij, and amin is the lower bound of aij.

3. Experimental Research

3.1 Basic Data Types and Basic Statements of Single-Chip C Language

We know that the data stored in the single-chip microcomputer is stored in 0 and 1, so in this case, the number of bits occupied by different data stored in the single-chip microcomputer is different, for example, a number 8 and a number 100000000, the space occupied by their storage It is definitely different. The purpose of defining the data type is to tell the microcontroller how much space the data to be stored takes up, so that the microcontroller stores it according to the type you define, so it won't waste space. Specifically, in the C language, for example, the int type occupies two bytes., an int type data occupies 16-bit storage space, and so on. The data types and distribution of the single-chip C language are shown in Table 1.

Table 1: MCU C language data type and allocation table

type	length (bytes)	scope
unsigned char	1	0~255
Signed character type	1	-128~127
unsigned short	2	0~65536
Signed short integer	2	-32768~32767
unsigned int	2	0~65536
signed integer	2	-32768~32767
unsigned long	4	0~4294967295
signed long integer	4	-2147483648~2147483647
Single-precision floating point	4	+/-1.175e-38~3.40e+38
Double-precision floating-point type	4	+/-1.175e-38~3.40e+38

C programs can be divided into three basic parts: sequential methods, branch programs, and loop programs. The C language provides many commands to implement these program functions. Common are expression statements, function call statements, control statements, complex statements and void statements, which are the basic knowledge of the C language. And the programming of general MCU application only needs to master these knowledge is enough.

3.2 The Main Links of Development

Introducing the course from the basics, from using the microcontroller program to turn on and off a lamp to the digital time clock behind, one by one practical project is completed step by step to realize the mastery of knowledge. Improve students' interest in learning in the classroom, and at the same time, through the study of the project content, students can better understand the microcontroller, which lays the foundation for students' self-study improvement in the later period, and provides students with more options when going out for employment in the later period.

The development of the single-chip teaching experiment system mainly includes the following links

(1) The choice of programming language

(2) Application of programming development software Keil C51

(3) Proteus draws and simulates circuit diagrams

(4) Application of single chip tester

(5) Electronic training to complete self-program verification and experimental board production

3.3 The Implementation Process of Integrated Teaching

(1) Project analysis

By reading the project task book, observing the equipment, and consulting relevant technical materials, students have group discussions and formulate a plan for completing the task.

(2) Project implementation process

The teacher's guidance process: explain the necessary task book → explain the relevant knowledge points → assign work tasks → observe the work process of each group and give timely guidance → record the performance of the students and give the training results.

Students' learning process: understand the work tasks and equipment → jointly analyze the accepted tasks → assign tasks within the group, determine roles → discuss and negotiate and formulate work plans → hands-on practice, mutual inspection → assembly and debugging → summary training report.

(3) Exchange of experience

The team leader reports the completion of the project → team members share the process and experience of completing the task → self-evaluation within the group → mutual evaluation between groups → record the innovative methods and good experiences used in completing the task.

Each time a project is completed during the experiment, the members of each group exchange roles, so that each student can gain the knowledge learned in different tasks. In this way, students can master the knowledge they have learned more comprehensively, and lay a solid foundation for cultivating automatic production line professionals in the field of modern industrial control.

4. Experimental Analysis

4.1 List of System Components

Before implementing circuit welding, we generally ask students to write a list of circuit components according to the circuit diagram, and then use the component list to find the relevant electrical components. The last step is to solder the circuit. Soldering is to weld and connect components according to the component layout (the connection can be operated according to the actual situation, the front and back of the circuit board can be lead, and jumpers can also be used appropriately), are shown in Table 2.

Table 2: List of Microcontroller Minimum System Components

serial number	Component name	component symbol	Specifications	quantity
1	resistance	R	1KΩ, 100Ω	Each 1
2	Electrolytic capacitor	C1	10μF	1
3	Ceramic capacitors	C2, C3	30pF	2
4	crystal oscillator	X1	11.0592MHz	1
5	MCU chip	U1	STC89C51	1
6	IC socket		40 feet	1
7	Terminals		8 bits	some
8	wire			some

When the small microcomputer system of the single-chip microcomputer is sold, it should be repaired to ensure that the circuit can work normally.

4.2 Status Statistics Table

It can be seen from the case of circular automatic production line processing that enterprises can use Witness software to dynamically simulate the entire operation process of the production system, allowing users to identify problems in the production process, adjust the production operation process through simulation, and improve the finished product of the production system yield and increase its production efficiency are shown in Table 3 and Figure 2.

Table 3: Buffer status statistics table in the working cycle after improvement

name	total entry	total discharge	Quantity on hand	maximum value	minimum	average inventory	average storage time
waste bin	289	0	289	289	0	141.54	235.08
buffer 001	5334	5334	0	32	0	1.98	0.18
warehouse 1	1377	0	1377	1377	0	683.96	238.42
warehouse 2	1356	0	1356	1356	0	686.61	243.05
warehouse 3	1306	0	1306	1306	0	641.47	235.76
warehouse 4	1286	0	1286	1286	0	644.58	240.59

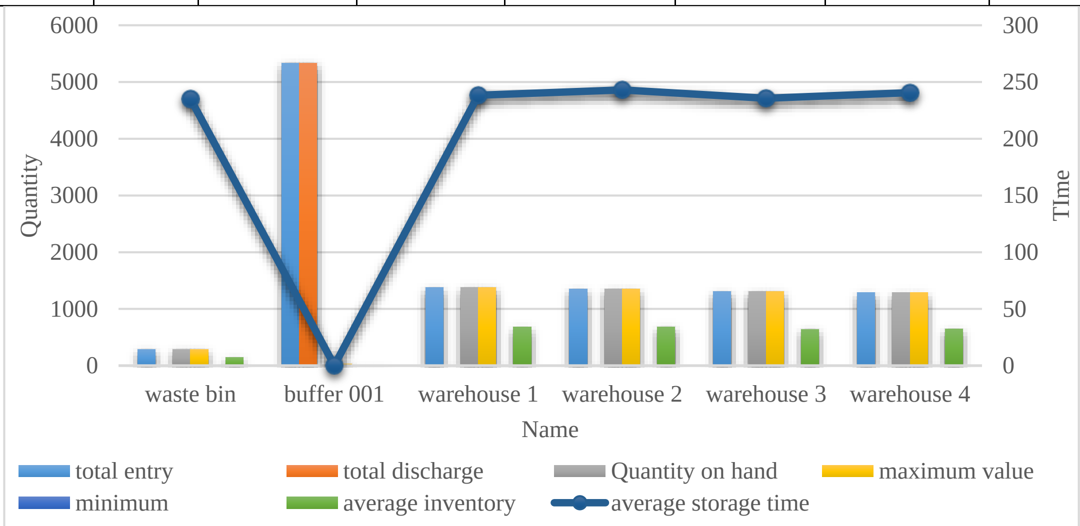

Figure 2: Buffer status analysis diagram in the improved working cycle

After re-simulating the input for 480 minutes through the Witness software, it was found that the phenomenon of massive blockage of the processing units disappeared after the system improvement, the busy rate of the four operating units was relatively balanced, and the efficiency of the production line was also improved accordingly. To increase the number of products processed and output, from the perspective of the total number of composite sets stored in the storage unit from 3,778 to 5,325, the production efficiency has increased by 40%.

4.3 Test Set Pattern Recognition Comparison

Comparing the pattern recognition results of the test set, it can be seen that the PNN has higher accuracy in the recognition of normal samples, but there are cases where the periodic pattern is judged as the normal pattern, while the optimized SVM has higher recognition accuracy on the periodic pattern, but there are cases where the normal pattern is judged as the normal pattern. In the case of cycle mode, other step and trend modes are similar in control charts, and there are a few cases of mutual misjudgment are shown in Table 4.

Table 4: PNN and optimized SVM comparison table

Algorithm type	PNN	Optimizing SVMs
Training set accuracy (%)	97.187	97.604
Test set accuracy (%)	97.083	97.500
Overall classification accuracy (%)	97.167	97.552

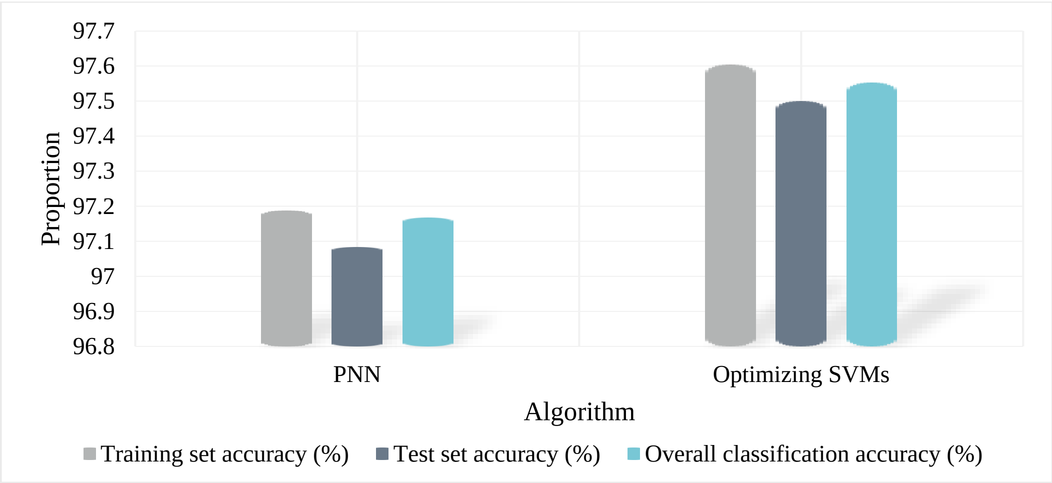

Figure 3: Comparative analysis of PNN and optimized SVM

By comparing the classification accuracy data in Figure 3, it is easy to conclude that the recognition accuracy of the optimized SVM in both the training set and the test set is relatively better than that of the PNN algorithm, that is, the classification effect of the optimized SVM is better in solving the control chart pattern recognition.

5. Conclusions

With the increasingly fierce competition in the global economy, flexible manufacturing technology, which is a key technology in today's manufacturing industry, is more and more widely recognized around the world, and the demand for such talents in the whole society is also increasing. However, as a first-line teaching application, the flexible manufacturing system has defects such as high cost, huge area and easy damage. In addition, from the current school conditions, domestic colleges and universities generally lack advanced training equipment in this field. There is a big difference between the theoretical knowledge and practical skills learned and the actual market demand, which leads to a serious shortage of talents in my country's flexible manufacturing industry. Therefore, it has high practical application value to develop the simulation experiment equipment for the actual production system.

References

[1] Hidalgo M C, Junior F K. Steady-State Sensitivities of Marine Propulsion Control Techniques[J]. Journal of Control, Automation and Electrical Systems, 2021, 32(3):543-562.
[2] VisanI. Diaconu E.M.emy_diaconu@yahoo.comValahia University of Targoviste, Faculty of Electrical Engineering, Electronics and Information Technology. Home Automation System Using ESP8266 Microcontroller and Blynk Application[J]. The Scientific Bulletin of Electrical Engineering Faculty, 2021, 21(2):59-62.
[3] Ayatinia M, Forouzanfar M, Ramezani A. An LMI Approach to Robust Iterative Learning Control for Linear Discrete-time Systems[J]. International Journal of Control, Automation and Systems, 2022, 20(7):2391-2401.
[4] Resende C Z, Carelli R, Sarcinelli-Filho M. A Path-Following Controller for Guiding a Single Robot or a Multi-robot System[J]. Journal of Control, Automation and Electrical Systems, 2021, 32(4):895-909.
[5] Farias G B, Maximo M R O A, Afonso R J M. Requirements Derivation for the Goalkeeper of the RoboCup Small Size League[J]. Journal of Control, Automation and Electrical Systems, 2022, 33(4):1329-1341.
[6] Theodoro T S, Barbosa P G, Tomim M A, et al. Comparative Performance of Three Phasor-Extraction Algorithms for Co-simulation of Electrical Power Systems[J]. Journal of Control, Automation and Electrical Systems, 2022, 33(2):561-573.
[7] Fogliatto M, Luiz D N, Ribeiro R, et al. Lifetime Study of Electrical Power Distribution Systems Failures[J]. Journal of Control, Automation and Electrical Systems, 2022, 33(4):1261-1271.
[8] Trentini C, Guedes W, Oliveira L, et al. Maintenance Planning of Electric Distribution Systems—A Review[J].

Journal of Control, Automation and Electrical Systems, 2021, 32(1):186-202.
[9] Pradhan P C, Sahu R K, Panda S. Analysis of Hybrid Fuzzy Logic Control Based PID Through the Filter for Frequency Regulation of Electrical Power System with Real-Time Simulation[J]. Journal of Control, Automation and Electrical Systems, 2021, 32(2):439-457.
[10] Pinto G, Amaral J, Pinheiro G, et al. Non-intrusive Internal Corrosion Characterization using the Potential Drop Technique for Electrical Mapping and Machine Learning[J]. Journal of Control, Automation and Electrical Systems, 2022, 33(1):183-197.
[11] Diniz F A, RS Alípio, Moura R. Assessment of the Influence of Ground Admittance Correction and Frequency Dependence of Electrical Parameters of Ground of Simulation of Electromagnetic Transients in Overhead Lines[J]. Journal of Control, Automation and Electrical Systems, 2022, 33(3):1066-1080.
[12] Prasad T N, Devi A L. Cost-Based Interlinking Converter Droop Control Strategy for Load Management with Improved Voltage Regulation in AC–DC Microgrid[J]. Journal of Control, Automation and Electrical Systems, 2021, 32(4):1071-1086.