Intelligent Computation in the Computerized Flat Knitting Systems

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Abstract:- Intelligent computation has got wide applications in textile industry in recent years. In this paper, we give a brief overview on the intelligent technologies we have employed in the computerized flat knitting systems recently. These intelligent technologies include compound agent, fuzzy logic, Petri net, cellular automata, genetic algorithms, chaos, and fractal geometry. Finally, we point out the future work for this topic.

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1.Introduction

Flat knitting machine, a major machine in woolen sweater production, is a kind of V-bed weft knitting machine. With the development of the computer and electronics technologies, the computerized controllers of flat knitting machines are constantly emerging in recent years. There are two parts of the computerized flat knitting machines, one is the computer controller in the flat knitting machine, and the other is the computer pattern preparation system. The computer pattern preparation system is used to design the knitting data for the computerized flat knitting systems. All knitting data needed for machine operation are programmed in the keyboard and simultaneously displayed on the monitoring screen. These data are composed of function control data and needle selection data. After the knitting data are finished, they are saved in a 3.5 inch micro-floppy disk. When a woolen piece is to be knitted, the stored data in the floppy disk can be fed into the controller by insertion of the disk into the driver in the controller panel[6]. The above procedures help the computerized flat knitting machine to meet the current fashion trend in short cycle and have great productivity. But one flaw for the computer pattern preparation system is that a pattern designer needs to spend much time to design a satisfactory pattern. Some recent emerging intelligent technologies could be helpful for the analysis and design of the satisfactory patterns. The intelligent methods we have employed are cellular automata (CA)[2, 3], genetic algorithms (GA)[4], chaos, and fractal geometry[8]. We have also employed Petri nets to analyze and examine the correction of the designed pattern date[12]. As for the design of the computer controller of the flat knitting machine, compound agent and fuzzy system technologies are used to improve the control performance[5, 11].

In this paper, we review the intelligent computation we have recently employed in the computerized flat knitting systems. In the next section, we introduce the knitting and control requirements of the computerized flat knitting system. In the third section, the intelligent computation applied to the flat knitting system is discussed. Finally, we give some proposals for the future work of intelligent computation applied to the flat knitting machine.

2.ComputerizedFlat Knitting Systems

2.1The Control Requirements

In the control of the flat knitting machine, the knitting data from the pattern preparation systems and synchronous signals from the flat knitting machine are handled by the computer to form control instructions. These control instructions are used to drive the output executors to carry out the knitting actions.

Generally speaking, the control system is required to have the following functions: (1) All knitting data from the pattern preparation systems can be fed into the controller by insertion of the floppy disk into the driver in the controller panel, or can be transferred to the controller by a communication network; (2) The knitting data currently used for each course can be displayed on the monitoring screen; (3) The knitting data can be modified and the modified data can simply be fed back to the floppy disk if needed; (4) Diagnostic operations of electrical parts can easily be done by maintenance mode in the software system; (5) The control data of cam operations, knitting speeds, fabric take-down speeds, racking positions, stitch positions and density, yarn assembly and needle selection should be included in all knitting data; (6) Various sensors and micro-switches should be checked and handled to complete various functions.

The output executors include a carriage motor, a fabric take-down motor, a rack motor, eight stitch motors, cam solenoids, yarn solenoids, selector solenoids, presser solenoids and so on. The input signals include various sensors and micro-switches, such as the course synchronous signal, the needle synchronous signal, the start/stop signal and trouble signals.

According to the control requirements, we have designed the control system using the structure of master-slave bus system. The master computer uses an industrial control computer (80586), while each slave controller uses a 8031 single-chip micro-computer. Each slave controller is used to control some specific executors, e.g., the needle selection controller is used to control the needle selection.

2.2 Knitting Requirements

All knitting data include the data of function control, pattern, yarn assembly, stitch density and a half needle racking position. In the function control data, there are the data of cam operations, knitting speeds, fabric take-down speeds, racking positions, stitch positions and density control, yarn assembly control and needle selection control and so on. The needle selection control data are obtained by developing patterns according to the pattern number, the pattern course and the pattern color in the function control data. The pattern data include the basic pattern data and the pattern developing data. The stitch density data are used to control motor drivers by stepping them in each knitting section. When a woolen piece is knitted, three kinds of above data are often used to form the control instructions.

In the flat knitting machine, the pattern number, the pattern course and the pattern color in the function control data at each course are used to transfer the basic pattern data to the needle selection control data of each selector system. The needle selection data are used to develop the pattern developing data during the real-time operation of the knitting machine. After that, the developed needle selection control data are transferred to control the needle selectors.

3. Intelligent Computation Applied to the Knitting Systems

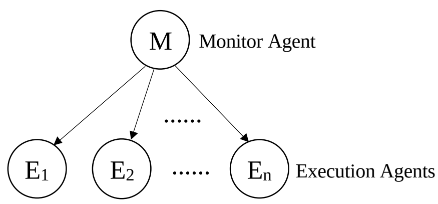
3.1 Compound Agent for the Design of the Flat Knitting Control Systems

Many artificial intelligent researchers are striving to build agents for complex, dynamic multi-agent domains. The compound agent is a special kind of the multi-agent and can be applied to real-world dynamic environments. The members of the compound agent, the sub-agents, have the common intention and belief, and commit common responsibility. They also employ community activity to achieve a common goal (i.e., the goal of the compound agent). One obvious characteristic of the compound agent is that the sub-agents of the compound agent strongly depend on each other, and each one takes the global benefit (i.e., the benefit of the compound agent) as its highest benefit. So the compound agent can be regarded as an entirety to view from the external world.

In order to ensure the cooperation and synchronization of activities of the sub-agents in the compound agent, we have proposed a explicit coordination model to meet the high coordination requirements of the compound agent based on Jennings' concepts of commitments and conventions[5]. The actions of the sub-agents in the compound agent are determined by the approximate fuzzy reasoning method. The rule base of the approximate fuzzy reasoning system can be adjusted on line with the direction of the monitor agent. The compound agent we proposed is more suitable for complex and dynamic environment. The fault tolerance capacity of the control system designed by the method of the compound agent can also be improved.

As we known, there are several shortcomings for most of the computer control system of the flat knitting machine, e.g., low capability of fault tolerance, and low capability of self-reparation. In order to improve the control performance of the flat-knitting system, we tried to design a novel control system using the method of compound agent.

According to the control requirements of the



flat knitting machine, we have designed the control system as follow: one master computer and twelve slave controllers. From the viewpoint of the compound agent (see Fig. 1(a)), the master computer can be thought as a monitor agent, and twelve slave controllers as twelve execution agents. The control system of the flat-knitting machine can be acted as the compound agent system, which is shown as Fig. 1(b). There are two main functions of the monitor agent. One is to assign and coordinate various subtasks and detail requirements to each of twelve execution agents when a new pattern design is going to be knitted, the other is to monitor the work status of each execution agent and deal with the faults when they happen. Twelve execution agents are used

to control twelve functional blocks, i.e., needle selection, cam control, yarn carrier selection, stitch adjustment, carriage movement control and so on.

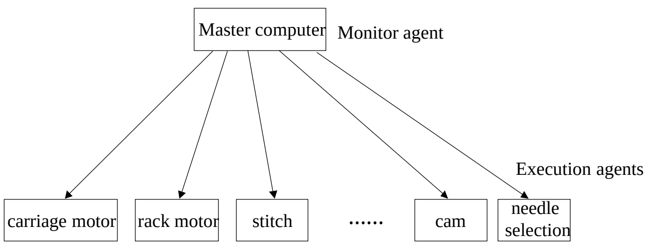


Fig. 1(b). The structure of the computer control system using the method of compound agent.

Each execution agent of the knitting machine should work coordinately when a desired pattern design was being knitted. For example, in order to finish a tuck operation, the execution agent of cam must control and ensure the tuck cam to be selected. At the same time the execution agent of cam should be coordinated with the executive agent of the needle selection. Moreover, the actions of the following execution agents should have been finished before the above actions of cam and needle selection: (1) The execution agent of the yarn carrier must ensure that the set-colored yarn is on the yarn carrier; (2) The execution agent of the carriage movement should ensure that carriage is at the desired position; and (3) The execution agent of adjusting stitch has already set the proper stitch value. If anyone of the above execution agents doesn't work properly, the tuck operation would not be fulfilled. The monitor agent would send a warning signal to all of the execution agents, and work again until the related execution agents to clear the faults.

3.2 Fuzzy Control of Needle Pre-selection

The recent advent of fuzzy system technology, which has the unique capability of computing with words and handling imprecision, uncertain and ambiguous information, has been proved to be an effective means for many practical problems. Fuzzy systems are universal approximators, so fuzzy system technology should be effective to be applied to the control of the complex flat knitting systems. In the control system of the flat knitting machine, needle selection is the basic and most important operation. We have employed fuzzy logic technology to control the number of the needle pre-selection[11]. The correction of the above method has been analyzed by using a fuzzy Petri net model[12]. We have proved theoretically and experimentally the superiority of fuzzy technology in the control of needle pre-selection comparing with the traditional methods.

3.3 Petri Net as the Analysis Methods of Knitting Data

Petri net theory is a kind of graphical and modelling tool applicable to many fields. It is easily to implement the computer representation of a Petri net. Then, the Petri ent can be used to simulate the dynamic behavior of the net (if one has defined the firing rule) and analyze the properties of the net. There have been various kinds of Petri nets, e.g., time Petri net, timed Petri net, and the synchronized Petri net (SPN). Also, there have already been many powerful Petri nets software tools and packages on different platforms.

In order to enrich the simulation analysis and mimic demonstration of the knitting processes, we have employed SPN to model the automatic knitting process according to the features of the flat knitting systems[12]. First, we obtained a physical model through the analysis on the knitting process. Based on the physical model, we then built a SPN model by defining the places, events and transitions with respective to the knitting actions. The method of linear algebra was used to describe and analyze the running of SPN. Finally, the SPN model was used to analyze the actions in the knitting processes, such as, the basic loop, the tuck, and the transfer. The analysis results demonstrated that the SPN model was helpful for designing the knitting data used in the knitting systems. The SPN model could be used to prove the correction of the designed pattern data in the pattern preparation system. As such, the contradictory data and the faults caused artificially could be avoided.

3.4 Generation of Patterns for Flat Knitting Machine

Before a woolen piece is going to be knitted, the patterns must have been prepared by the pattern preparation system. It costs much time to design a large and complex pattern. Also, it is difficult to design a beautiful, complex pattern with high creativity and strong human artistry. Dynamically spatiotemporal behaviors of CA could be used to generate various complex patterns, some of which are chaotic and fractal patterns. Some other methods to generate chaotic and fractal patterns could also be employed. The designed patterns using these intelligent technologies make the woolen products have a strong appeal to the market. Now we introduce these intelligent methods in the generation of patterns.

3.4.1 Cellular Automata

CA are parallel mathematics models. CA are discrete in time, space and state. Interests have recently been revived in CA models to explore spatiotemporal complexity. Based on statistically observed long-term behavior of CA, Wolfram[10] suggested a classification of CA which appears to fall into four classes, where class 1, 2 and 3 are roughly analogous respectively to the limit points, limit cycles and strange attractors found in low dimensional, dynamical system, while class 4 exhibits complicatedly localized and propagated structures. CA are of great interest for modelling complex physical systems or synchronous parallel processes. CA may be considered as information-processing systems, or evolution performing some computation on the sequence of site values given as the initial state. Hence, the complexly spatiotemporal behavior of CA can be used to provide a new, intelligent method for designing pattern data for the flat knitting systems. Moreover, many patterns generated by CA exhibit chaotic or self-similar, fractal behavior[1, 7, 9].

We have used one-dimensional (1D) and two-dimensional (2D) CA to generate needle selection data of the knitting system[2]. In 1D CA, only an initial value and a local rule need to be given. 1D CA evolve at each time-step (course) and generate the pattern data of the next course, which can replace the procedure of computing needle selection data of the next course in the computer controller. 2D CA are used to replace the huge work of making patterns in the pattern preparation system. Several possible lattices and neighborhood structures for 2D CA have been considered. Neighborhood structures could be five-neighbor square and nine-neighbor square referred to as the Von Neumanmn and Moore neighborhood respectively. Triangular and hexagonal lattices are also possible for the structures of CA. Some complex patterns generated difficulty by 1D CA can be generated by 2D CA. These patterns are stored in a disk and can be used when they are needed in knitting a woolen piece.

Furthermore, we also integrated CA with some intelligent technologies in soft computing and obtained many variations of CA[3], such as the parallel genetic CA, fuzzy CA, neural CA. Some of them are also employed to generate the pattern data.

3.4.2 Genetic Algorithms as the Iterated Rules of Cellular Automata

Gnetic algorithms have been successful as robust algorithms for optimization, searching, classification and other difficult tasks. GA is a stochastic optimization method for combinatorial optimization problems. GA are based on multi-point search and use crossover operation, so GA have more chance to obtain good solutions. In[4], we have developed a parallel GA as the local rule of CA (PGCA). Based on the random initial values of the 2D lattice, we can use the PGCA to optimize the pattern data.

Let us now suppose that a large population of individuals lies on a 2D grid, one individual per grid point. The updating rules are similar to the typical GA. The value of fitness function is computed at any grid site independently. Crossover is applied in the following way: a given cell selects the fittest one among its four nearest neighbors and single point crossover is performed between the bit-string representations of the given individual and of the fittest neighbor. The crossover point is chosen at random. Then the fittest individual among the two offsprings and the original point replaces the original individual. The crossover operator as defined here is a local operator: selection and recombination take place within a small neighborhood. This is different from the way in which crossover is traditionally used: some form of biased stochastic selection of individuals from the entire population, followed by random mating. Mutation can be applied with a given probability to any cell by randomly flipping a single bit in the trial point with the bit-string representation.

In the PGCA models, if a 8-bit-string is used, 256 kinds of colors in a pattern may be obtained. In our knitting system, only 8 colors are need, so a 3-

bit-string is enough. That means, the bits of a string determine the color number of a pattern.

3.4.3 Chaotic and Fractal Patterns

Besides the CA, we have also studied some other methods for the generation of patterns, especially the chaotic and fractal patterns. In our pattern preparation systems, string rewriting systems, iterated function systems, and Julia sets have been employed to generate the chaotic and fractal patterns[8].

4. Conclusions

In this paper, we have provided a brief overview on the intelligent computation we have employed in the computerized flat knitting systems in recent years. A novel method based on the compound agent system is employed to design a more reliable flat-knitting control system. The fuzzy and fuzzy Petri net technologies are used to the control and analysis of the needle pre-selection system. Some researches on the analysis of pattern data using Petri net is also discussed. Furthermore, some intelligent methods, such as CA, GA, chaos, and fractal geometry, are used to generate beautiful, complex patterns in pattern preparation systems. The products with these patterns have a strong attraction to the consumers. The control system with these intelligent technologies can also be applied to other knitting systems such as the acircumferential machine, the printing and dyeing systems, and other analogous systems.

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