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The Data Fusion of Chess-Playing Robot Based on SERCOS

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Abstract. This paper presents a data fusion system of chess-playing robot based on SERCOS. Owing to the environment of Windows NT + RTX, especially the SERCOS bus interface card, the control system is excellent in real-time property, more importantly, the highly efficiency of data fusion and image processing is guaranteed and therefore the good interaction between people and robot is ensured.

Overview of the Chess-Playing Robot

The chess-playing robot is the combination of the following high-tech: computer, artificial intelligence, automatic control and optic-mechanical-electronic. It is a kind of service robot with wide-range functions and adaptation. We designed this one from the general robot through externality alternation and hardware design, and at the same time various entertainment software development. In order to make this robot the really excellent integration of robot and Chinese traditional chess-playing art, we applied all kinds of high-tech such as calculating and memorizing capability of computer, logic reasoning and judging ability of artificial intelligence, developing and reliable optic-mechanical-electronic technology, authentic chessboard and chessman. Through hardware design, the chess-playing robot is humanoid and can interact with people in higher level, for example, audio and video, etc. And through various chess-playing software development, it can play the chess with people intelligently. Here, range of the chess is wide and we can design different software to broaden the adaptation of this chess-playing robot. In this paper, the author focused his attention on Chinese chess and therefore all the following are based on it. For the reason of the open architecture of this robot, it is easy for us to develop the familiar one playing other chess and games. The following Fig1 is the flow chart of the chess-playing robot.

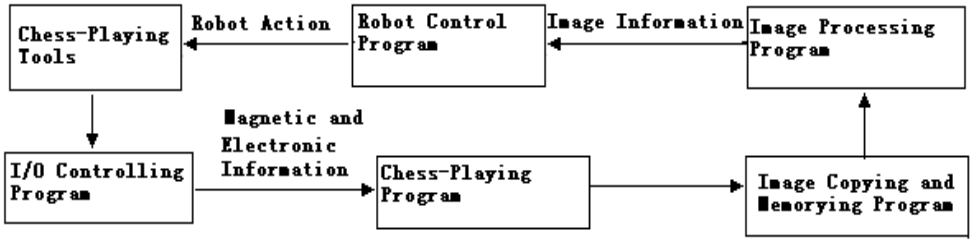


Fig1 Working flow of the Chess-Playing Robot

In addition, the information extraction, target identification and real-time motion control[1~3] become the key points of realizing high-level interaction and self-learning of the machine and the player.

SERCOS Protocol and Overview of its Application

SERCOS[4~6] (serial real time communication system) is a field bus interface and data communication protocol used in digital servo system and drive system. It can achieve real-time communication between industrial computer and digital servo system[6], sensors and programmable control unit's input and output. In 1990, Germany presented and began to establish SERCOS. This

protocol, whose operation, communication, modulation and so on are all based on international standard, presented the detailed interface explanation between open control unit and intelligent digital servo. It offered three modules for motor control, namely, velocity modular, position modular and torque modular. And more, you can choose any of them as the main modular and the other as aided one freely. The fiber optic transfer loop may support the 2/4/6/8/16 Mbits/s transfer speed. In data communication, it offers synchronous data exchange and asynchronous service channel. The latter permits the user to access digital motors in his will and send command. The synchronous channel can communicate with motors only after the configuration of the initialization phase and at the same time provide exchange channel for co-operation of motors. The strong points of this standard are as following:

(1) Standardization: All the basic operation, communication and assignment, etc accord with international communication standard IEC61491 (2002)[6].
(2) Openness: The establishment and technology of SERCOS are all open to the world.
(3) Compatibility: The function of interface card has nothing to do with operating system and hardware platform.
(4) Real-time: With the fiber optic as transfer line and just only the 4Mbits/s transfer speed, it can satisfy various data transfer requirement in the application.
(5) Expansibility: We can expand the SERCOS interface card through level connection and then every fiber optic loop can connect 256 points at most.

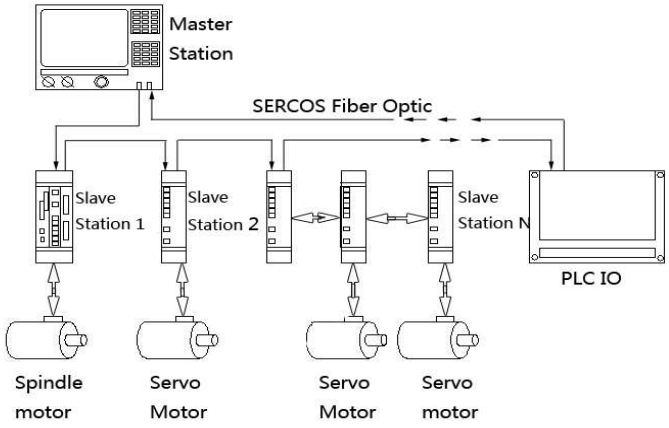


Fig2 Interface of SERCOS

SERCOS interface Fig 2 is made up of one master station and several slave stations (1 to 254 servos, main axis or PLC-IO). They are connected by fiber optic and then become loop net. The most distance between stations is 80 meters (plastic fiber optic) or 240 meters (glass fiber optic) and the communication speed, 2 Mbits/s or 4 Mbits/s, respectively. With this kind of structure, especially the relatively high transfer speed, we can implement excellent task of information transferring in data fusion and command transferring in motion control.

The SERCOS protocol defines the master synchronous telegram (MST), asynchronous telegram (AT) and master data telegram (MDT). MST, which means the beginning of one data communication cycle, is from the master station to all slave stations. The master station controls the synchronization of SERCOS interface by MST. AT is from the slave station to the master one, which feedbacks all kinds of servo information, such as servo axis position, rotate speed, torque, alarming signal, detecting signal, status responding signal, PLC input, servo parameter and motor parameter, to the master station. MDT, which sends the control command to the slave station, is from the master station to the slave. For instance, the servo axis position command, rotate speed, torque, the choice of working means, PLC output, servo parameter and motor parameter, etc. All the slave stations can receive this data link and locate the data in the specified position.

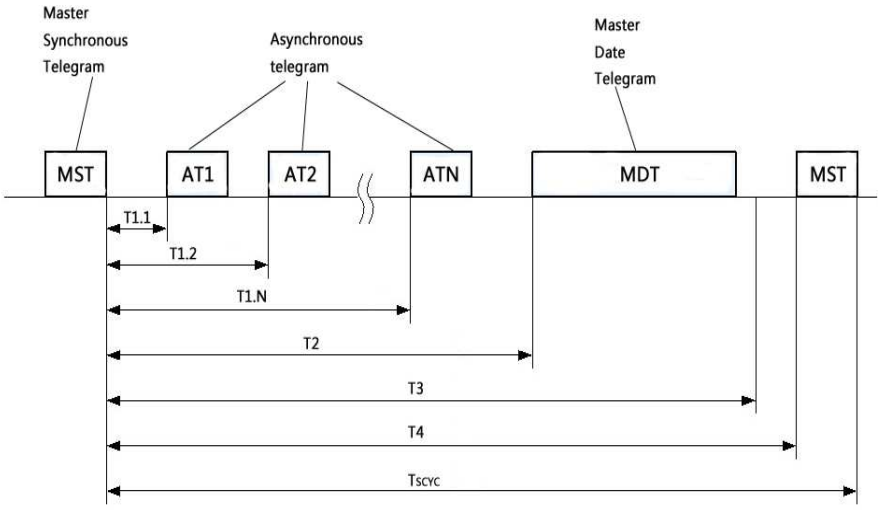


Fig3 Working time sequence of SERCOS

Fig 3 is the working time sequence. The system working cycle, decided by the control modes and the number of the slave stations, is optional as 0.062, 0.125, 0.25, 0.5, 1, 2, 3, …65ms. The SERCOS protocol states that the master station must finish configuring the parameter of the network communication in the initialization phase. It includes the system working cycle Tscyc, the sending time of all the slave stations, such as T1.1, T1.2, T1.3, ⋯ , T1.n, the position of the slave stations' data (MDTx) in the MDT data chain and the length of MDT.

After the initialization of system, SERCOS runs according to the time sequence of Fig 2. Comparing to the other industry field bus, the SERCOS has the following characteristics:

(1) Strictly synchronous and real-time transfer of data;
(2) Highly efficient transfer of the valuable data because of no checking and no responding;
(3) Although the Atx and MDTx are sent and received at different time, we can regulate their sampling and effective time through controlling the relevant parameter. And we can also separate various system parameters, such as servo gains, the highest rotate speed of motor, and the limit of motion and so on in some Atx and MDTx to transfer as asynchronous data. Such working mode makes sure of parallel transferring of not only synchronous command but also a great number of system parameters.

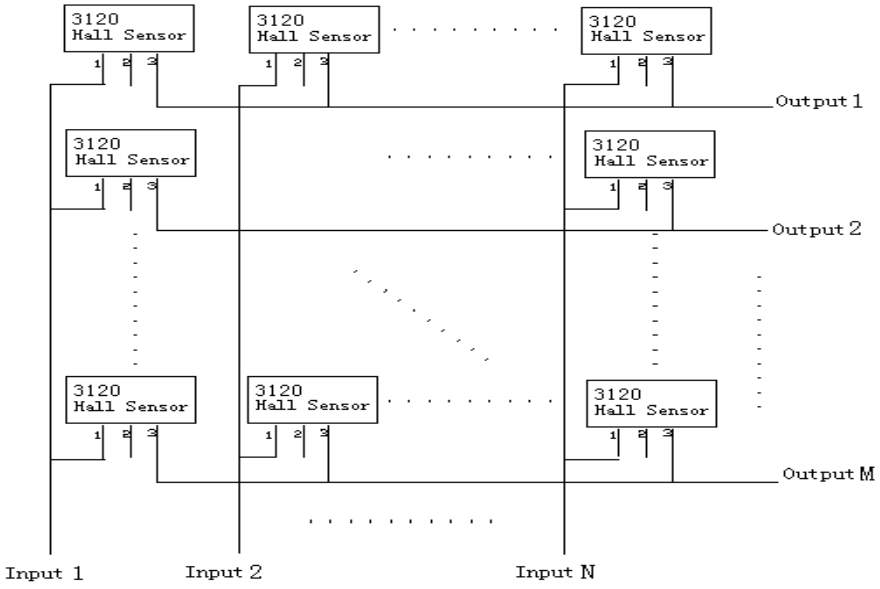
Consequently, we will take full advantage of this configuration process to meet the high demand of transferring. Not only information about magnetic, electronic and image, but also command about robot motion control can be transferred between robot and its controller.

Information Acquiring Based on Data Fusion

In order to make the chess-playing robot process smoothly, we should get not only the impact of people to the chess-playing tools but also the responding information of the robot. First, when people take some action, we had to acquire the changing information of the target (chess-playing tools) and send it to the robot. The information is the integration of the magnetic, electronic and image signals by means of relevant sensors in the chess-playing tools. Of course, there must be certain analysis program to process them. Next, the robot runs the chess-playing program and analyses information just received, responses and sends command to make the robot move. Therefore, a process of information transferring, made up of target identification, information extraction and motion control is there. From the above description, it is no doubt that the reliable sensors, efficient processing program based on data fusion and real-time transferring based on SERCOS are the key points to the high-quality robot.

We made some alternation to the chess-playing tools that are embedded with the hall sensors (for judging the existence and position status of the chess-playing tools). The hall sensors make sure that the responding time is suitable enough for our target identification. The output ports of the SERCOS bus control the power supply of the sensors in the columns, one port controls all sensors'

power supply in one column; and the input port of the SERCOS bus get the signal of the sensors in the line, one port gets all sensors' signal in one line (there is a N lines and M columns array of hall sensors. Fig4). In detail, there are two scanning processes. First, turning on the power supply of one column. Next, scanning all lines for some signals to detect where the chess-playing tools are. Then turning on the power supply of the columns in turn, also by means of detecting all the lines, we can get the status of the chess-playing tools in this column. After a cycle of this kind of scanning and detecting, we get the overall position status of all chessmen on the chessboard. Just as described above, whenever there is change about chessman on the chessboard, we can get necessary and enough information through calling the scanning and detecting program once. And also this program is always running to detect any change of the chess-playing tools in terms of let the robot know the changing position information of chessmen on chessboard.



Note:Pin 1 of all the sensors is power supply (DC 5-20V),
Pin 3 of all the sensors is signal output,
Pin 2 of all the sensors is common ground.

Fig4 Hall Sensors Array (M lines * N columns)

The magnetic and electronic signals give us some information of the chess-playing tools. When there is some action from people, the magnetic and electronic information are converted and subsequently enter IPC through SERCOS bus. As the result of the chess-playing program running in IPC, the image about the chessboard and chessman is copied and memorized as well. Of course, there is some relevant program to do that. Then, in order to attain the information of the chess-playing tools, we designed relevant signal processing, image analyzing and processing program according to different characteristics of the chess-playing tools. When we get the information of the chessmen, we can take advantage of chess-playing software to get the responding action of the robot. Such program and the intelligent program library are running in IPC. So we can make full preparation for the robot to operate the tools after image copying, memorizing and analyzing of the chess-playing tools. Here, just by virtue of strong points of data fusion, the chess-playing process becomes smooth.

Now, we get the necessary information, the outcome of the analysis and the responding action we wanted to make. What we need to do next is motion control. It is no doubt that the transferring of motion control command is the key to the real time property of the robot motion control.

Command Transferring Based on SERCOS

It is well known that robot control system is a real-time control system with multi-tasks executed simultaneously. And the motion control system is much stricter in real-time, security, robustness, and so on. By virtue of the strong points of the SERCOS bus, we chose the SERCOS bus interface card from INDRAMAT Corporation of Germany[5] as the transferring bus between robot and servo system. At the same time, the effective development tools are used here to promote our application.

With the capability of SERCOS and DSP, the author designed robot controller with the performance of multi-axis motion simultaneously and made it full of openness and modularization. Between every modular there is clear data structure and the whole system can be regarded as the construction, transfer and execution of data. Applying such motion controller to those of industrial robot will be the best choice because we can not only ensure the accuracy and necessary synchronization of motion control but also fulfill the real-time performance. Based on this open architecture, the author tried his best to conform to the international standard, in other words, the SERCOS standard. Hence, the multi-axis control with the SERCOS bus is the trend of upcoming robot system. It is decided by the openness of SERCOS standard and something like that.

The application of DSP isolates real-time requirement of SERCOS to CPU in hardware consideration and makes it possible to adopt different operating system, even soft, time-sharing operating system. DSP is responsible for the performance of SERCOS, sending commands and communicating with SERCOS, etc. In addition, it makes SERCOS interface accessible to the upper layer according to the requirement of CPU, which means that CPU can directly call SERCOS interface without SERCOS layer and send command.

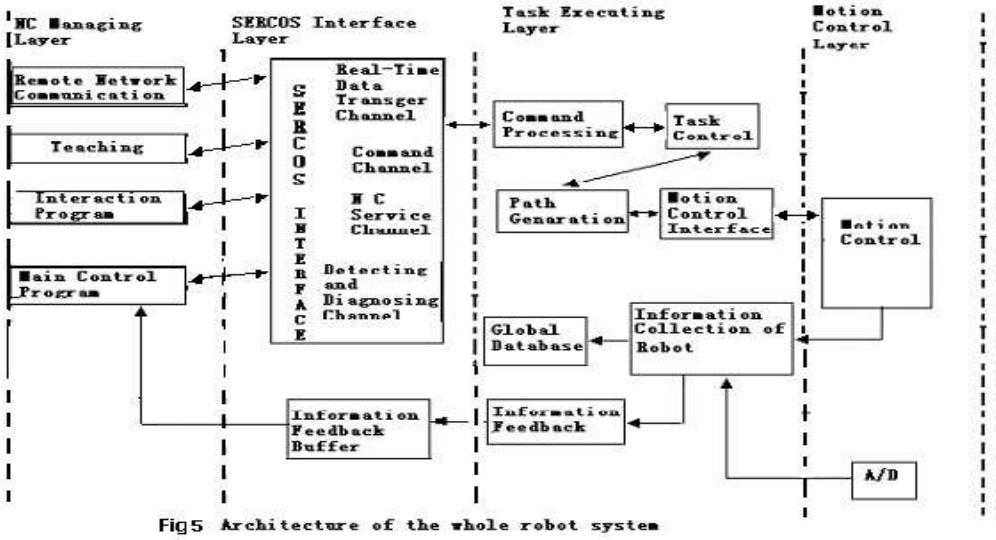


Fig5 Architecture of the whole robot system

Fig5 is the architecture of the chess-playing robot. The SERCOS interface layer is very important to the smooth run of the robot because it is SERCOS and its interface card that mainly guarantee the real-time property and something like that from hardware and software consideration.

The SERCOS bus interface card is connected to the IPC by EISA bus and wired to the robot servo system by fiber optic. So, it links the IPC and the servo system. The SERCOS bus provides IPC and robot servo system totally 6 communication channels for the aim of transferring data stream and command stream.

Real-time data transferring channel: It is made up of command channel and real value channel. The former transfers the real-time data from the path-planning module to the servo system. The latter feedbacks the real value (including the real value of the robot and the chessmen on chessboard) to the path-planning module after relevant commands (position, velocity, acceleration).

Command channel: This channel is aimed at transferring command number to servo driver and activating the inner command or function to control motion of the robot.

NC service channel: The command control module, transferring general, non-real-time data, real-time data and command to the servo driver, uses this channel.

Supervising and diagnosing channel: It can supervise the servo system, the execution process of the robot arm and transfer the data when in trouble.

Conclusion

The robot is based on general operating system—Windows NT and RTX from VenturCom Corporation[7]. High-capability SERCOS bus and its interface card, which transfers various real-time data and commands, can realize real-time position and motion control with high accuracy. The whole system is friendly in graphic user interface, excellent in management and can performance high-real-time controlling algorithms. In control system software design, the modularization makes it convenient to modify and append controlling algorithms. Its better expansibility and agility guarantees the real-time property and high-intelligence of the interaction between robot and player. The whole system is run in practice and proven to be effective, reliable and high quality.

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