Realtime Control of Robots Using Intel® Architecture

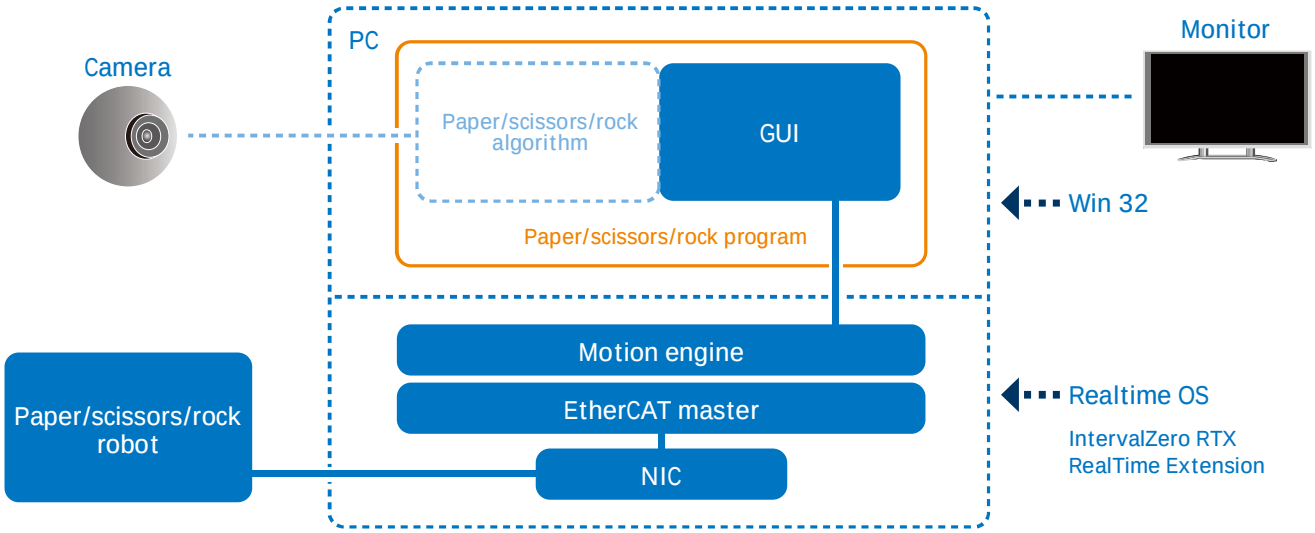
Paper/Scissors/Rock Robot that Always Responds to Human Partner with a Winning Hand

To demonstrate the potential of the Intel® architecture in embedded systems applications, Soft Servo Systems, Inc. has used the latest Intel® architecture to create a robot capable of playing the paper/scissors/rock game. A camera on the robot determines the hand shape made by the human player and the robot responds with a winning hand within only 200 milliseconds. The robot system consists of a camera to capture the human's hand shape, a control box that analyzes the camera image and issues instructions telling the robot what to do, and a robot mechanism that forms the specified hand shape. Unlike past robots that are controlled using special hardware, a major feature of this system is that the robot mechanism is controlled entirely by the Intel microprocessor in the control box (an Intel® Atom™ processor designed for embedded computing) together with the various software modules developed by Soft Servo Systems.

Software Configuration Combines Windows* with Realtime OS

The control box runs both Windows* and a realtime OS as operating systems. The highest execution priority is given to the realtime OS processes to ensure a level of realtime performance equivalent to a conventional standalone realtime OS. Accordingly, execution of Windows* processes is entirely subordinate to the realtime OS. The paper/scissors/rock program runs under Windows*. The role of this program is to analyze the camera image to determine the hand shape made by the human player and then send a command to the motion control program (motion engine) running under the realtime OS instructing it to make the winning hand shape.

The motion control program and EtherCAT* master run on the realtime OS. The motion control program generates robot movements to move the robot's hand smoothly to the shape specified by the paper/scissors/rock program. The EtherCAT* master handles communications between the control box and robot mechanism. EtherCAT* uses the Ethernet port included as a standard feature on PCs and is an open standard for high-speed servo networks for controlling machinery, robots, and other equipment.



Sophisticated Paper/Scissors/Rock Recognition Algorithm and Specially Designed Motion Engine

The paper/scissors/rock program that runs on Windows* uses a paper/scissors/rock recognition algorithm developed by Taizo Umezaki, a professor at the Graduate School of Engineering at the Nagoya Institute of Technology, that identifies the shape made by the human player's hand from an image captured by a camera. The paper/scissors/rock recognition algorithm utilizes a neural network which is an idealized representation of the way in which the human brain uses the propagation of nerve signals to make decisions. The algorithm extracts features from the image of the person's hand and then passes these to the neural network to determine the most likely hand shape. The paper/scissors/rock robot uses a very complex neural network configuration to improve the accuracy of recognition. Although the program needs to perform look-ups from a very large number of tables, the high-performance Intel processor can perform the associated processing and recognition very quickly.

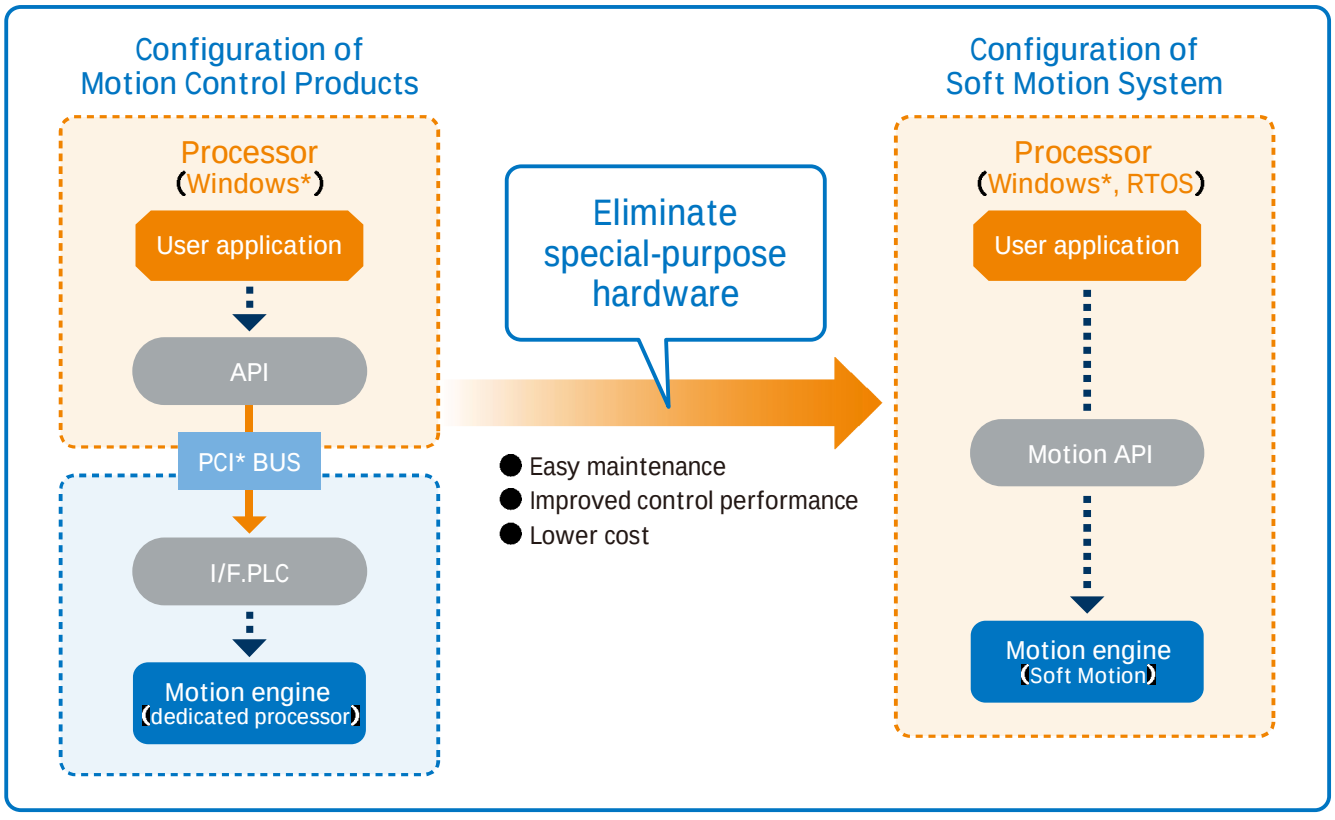
Once the human player's hand shape has been determined, the hand shape required to win the paper/scissors/rock game is sent to the motion engine running on the realtime OS. It is the task of the motion engine to generate the actual robot movements required to form the specified hand shape from among the three options, i.e. paper, scissors, rock. The motion engine generates smooth movements of the robot's fingers in one millisecond steps which it transmits to the robot mechanism in realtime via EtherCAT*. Although the paper/scissors/rock robot is only programmed to perform these three movements, the motion engine was designed to be capable of forming any desired finger shape. It would be possible, for example, to develop a robot that could copy any hand shape made by a person.

*Fingar mechanism of the Paper/Scissors/Rock robot is supported by Harmonic Drive Systems Inc.

Specially Developed Soft Motion Technology Generates Smooth Movements in the Paper/Scissors/Rock Robot

The sophisticated motion control at the core of the paper/scissors/rock robot uses Soft Motion technology developed by Soft Servo Systems for use in various industrial machinery and other equipment. This technology is based on basic research conducted at the Massachusetts Institute of Technology (MIT) and is now capable of implementing ultra-fast, ultra-high-speed motion control with a very high number of degrees of freedom entirely in software. From its formation, Soft Servo Systems made a deliberate decision to utilize the PC as its platform of choice for motion control. Products that use the company's Soft Motion technology include ServoWorks designed for use in numeric control machine tools and other industrial equipment and the SMP series for general-purpose positioning control systems. When running on a PC fitted with the Intel® processor, the software is capable of simultaneously controlling up to 64 axes with sub-nanometer accuracy.

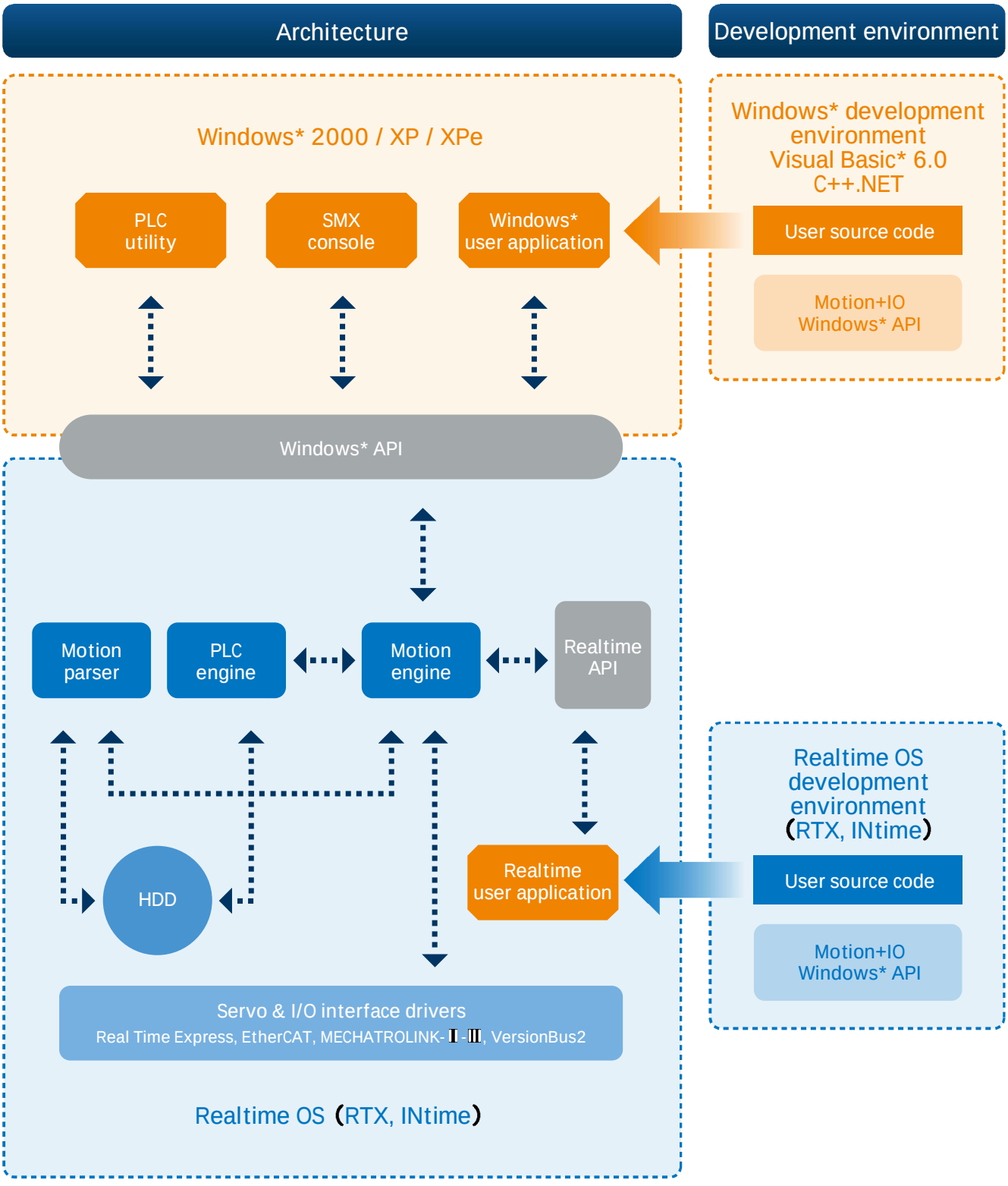
Although other companies offer PC-based solutions for motion control in industrial machinery and other equipment, most of these rely on special-purpose circuit boards (motion control boards) to perform the final control of the machinery. The hardware on these boards includes an embedded processor that performs a variety of different processing functions and a network interface for communication with the machinery. Although the PC is used to run GUI-based motion control software, its use is restricted to functions like process programming, supervisory control, and monitoring. The actual motion control is handled by the embedded processors on the special-purpose circuit boards. However, these solutions are heavily dependent on electronic parts manufacturer and there are doubts about their long-term availability and maintenance. Also, because high-end products are designed using large circuit boards, they cannot be mounted in compact PCs.



Taking Maximum Advantage of Superior Processing Performance of PC Processors

Something that Soft Servo Systems has been aware of since its formation has been the impressive pace at which the performance of PC microprocessors has continued to improve. Compared to the embedded processors used in special-purpose circuit boards, PC processors have achieved rapid improvements in processing performance.

This led the company to develop an entirely software-based solution that uses the PC's high-performance processor for all processing. The solution uses both Windows* and a separate realtime OS, with Windows* being used for the operations that require a user interface and the realtime OS for functions such as motion control and communication with the machinery. This combination of Windows* and a realtime OS can take advantage of the best features of both environments. In the case of Windows*, these include its high level of affinity with PCs as well as its graphical user interface (GUI) and networking capabilities, whereas the merits of the realtime OS lie in its ability to execute computational and input/output processing with a high level of realtime performance and with cycle times of a few milliseconds or less.



Development of Ideal Product for Embedded Applications Using Intel® Atom™ Processor

There is a growing need in the field of embedded systems to shrink the size of the PCs or dedicated control boxes used to control machine tools, robots, and other equipment. The answer to these needs lies in the Intel® Atom™ processor designed specifically for embedded computing. The Intel® Atom™ processor keeps power consumption and heat generation to a minimum while still delivering the superior processing performance demanded by modern embedded systems. It also allows designs that do not require a fan to cool the microprocessor which makes miniaturization much easier. Because the Intel® Atom™ processor inherits the Intel® architecture with its extensive history of use in the PC and server fields, software developed for PCs can be run without modification. In adopting the Intel® Atom™ processor, Soft Servo Systems has not only produced a motion control solution that runs on a PC, it also intends to continue working on embedded solutions where the need to make equipment housings even smaller is a key consideration.

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