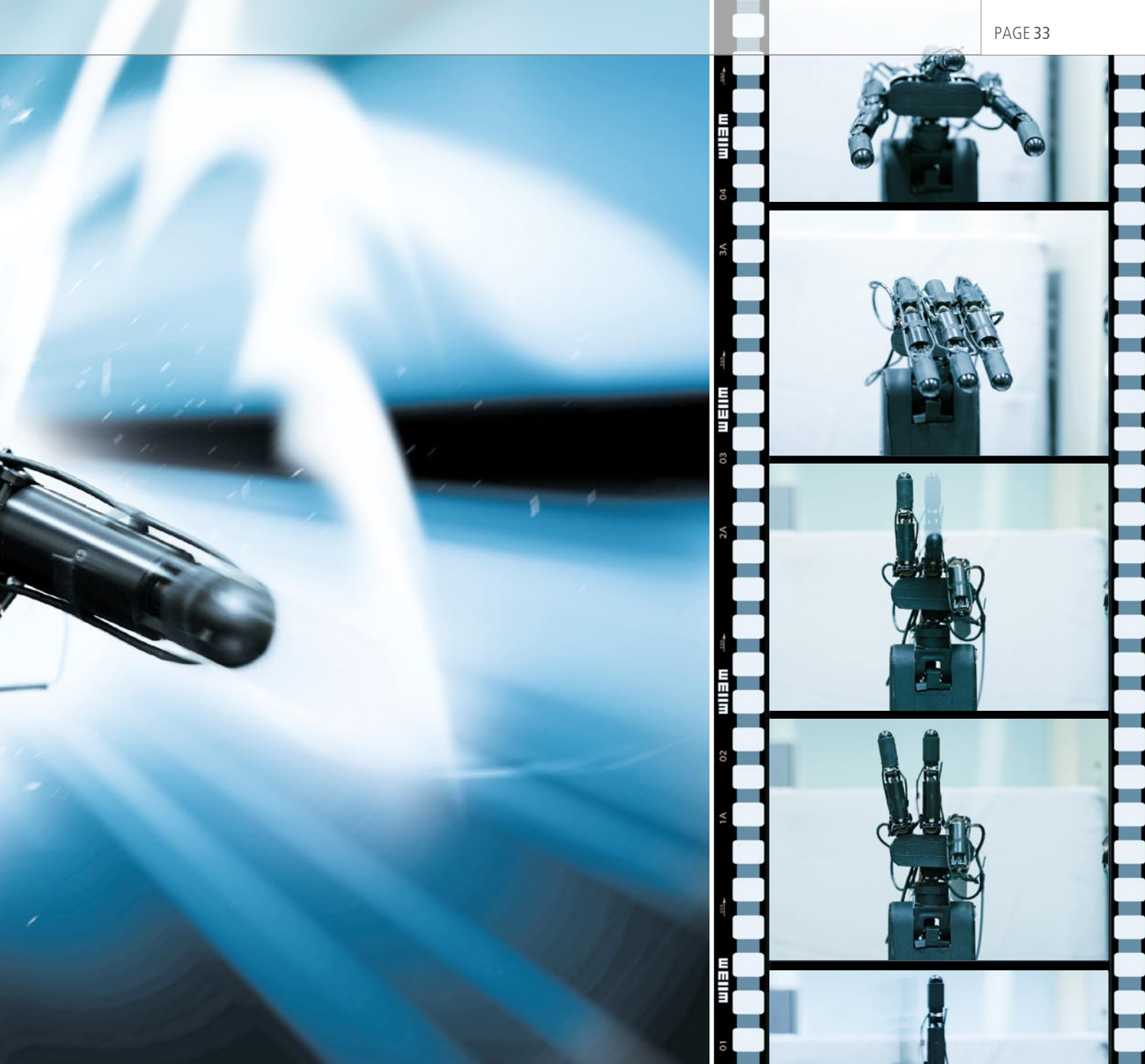


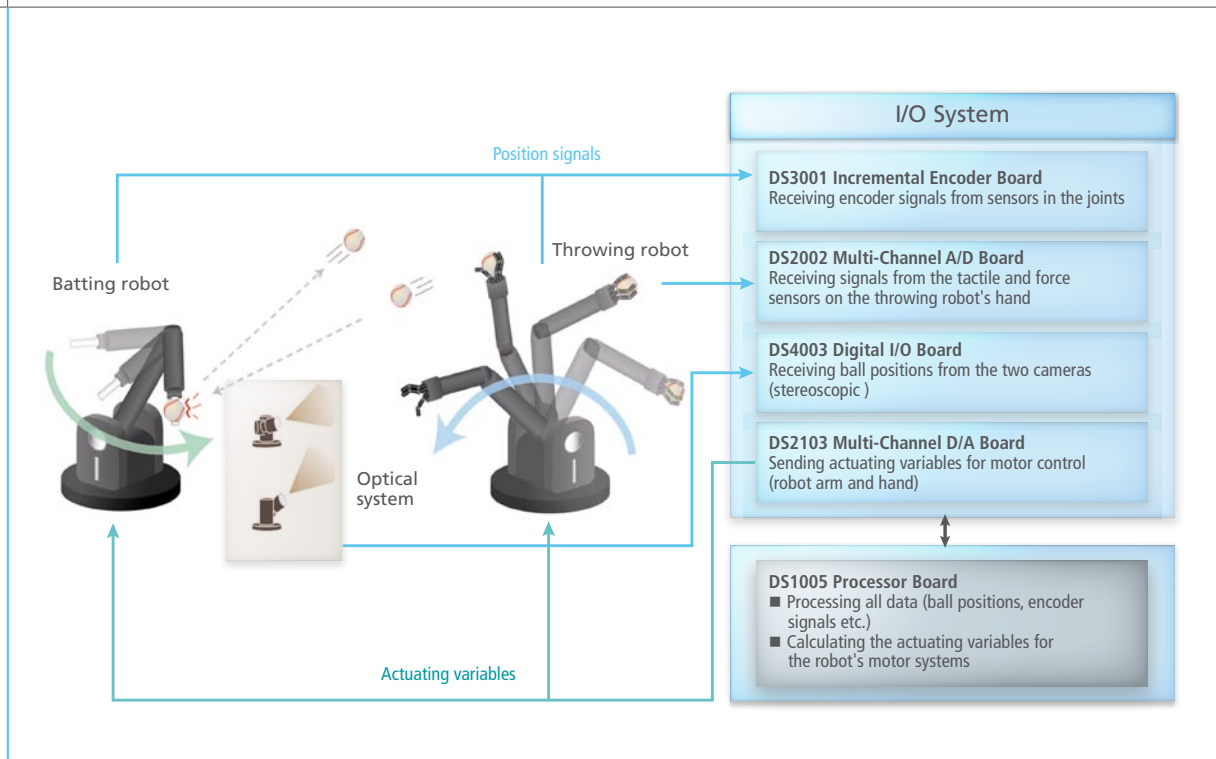


Home Run in Lab

Baseball-playing robot system demonstrates perfect and quick pitching and batting technology



Ultra-high-speed robots are expected to open up new fields of applications. With extremely high kinematic performance and stupendous cognitive capabilities, they surpass the human processing ability and challenge the limitations of machines. A project based on two robots at the University of Tokyo demonstrates the state of current research.



The throwing and batting robots are arranged like baseball players. The dSPACE system evaluates signals from sensors and a stereoscopic camera via several interface boards to calculate the motor control values.

Human Cognitive and Kinematic Abilities

In contrast to conventionally developed computers, the human brain is highly adaptable. This is because the brain is not a closed system comprised of the nervous system, but an open system that obtains information from the outside world through a very large number of sensory organs. It uses multiple kinematic control functions to affect the outside world, and it can also increase its adaptability and learning ability through the exchange of information with the outside world.

Pianists, circus acrobats and jugglers are examples of the ability to perform highly flexible, reliably harmonized cognitive and behavioral functions.

The Ultra-High-Speed Robot

The aim of a research project at the University of Tokyo was to construct an ultra-high-speed robot system capable of far exceeding human or conventional robot performance. To achieve the speed performance, the specifications included the following components:

- Optical system capable of processing the image data – including taking, sending, and calculating images – within 1 kHz.
- Lightweight robot hand with three fingers – the lowest number for stable manipulation – featuring miniature motors with high torque-to-weight ratio.

be obtained at 1 kHz. The high-speed hand, jointly developed with Harmonic Drive Systems Inc., can open and close 180° in 0.1 seconds. The optical sensors and processors of the optical system were developed with Hamamatsu Photonics K.K. Designing the camera head as an active vision system with a 2-DOF

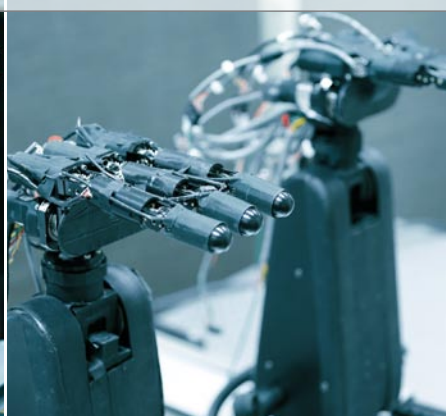
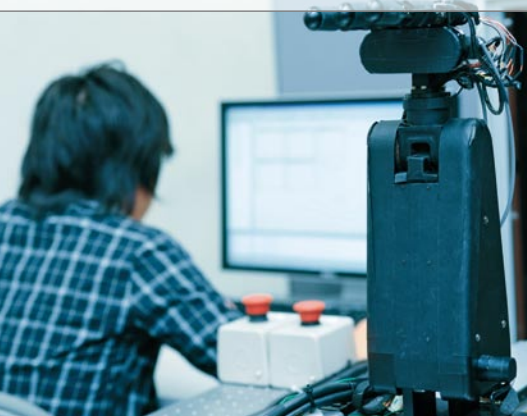
“With the modular hardware from dSPACE we were able to set up a robust, high-performance real-time system for our high-speed robots.”

Dr. Taku Senoo, University of Tokyo

System Design

The system built in this research project consists of a robot arm, robot hand, optical system, several sensors, and a real-time control system based on dSPACE hardware. Around the tips of the fingers of the hand are film-type tactile sensors, while force sensors are fitted to the joints of the fingers, allowing data relating to contact with objects to

(degrees of freedom) mechanism able to pan and tilt allows tracking control that can keep an object in the center of the field of vision as with the movement of the human eyeball. The stereoscopic vision based on two active vision systems allows reconstruction of three-dimensional shapes. The control software for download to dSPACE system was developed using MATLAB®/Simulink®.



Baseball Experiments

In the experiments, one robot plays the role of the thrower (pitcher), while the other plays the batter. In throwing, steadily migrating the speed peak time from shoulder to fingertips increased energy propagation efficiency and resulted in a high-speed, smooth swing. In batting, distributed control of the motion of swinging the bat at high speed and the motion of following the ball made it possible to respond to and strike a curve ball while swinging at high speed.

Score

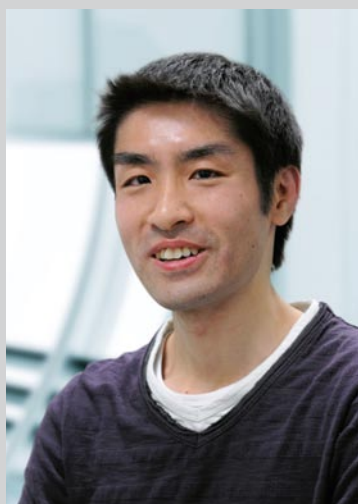
The result was a system in which a batting robot situated 3.9 meters from a throwing robot was able to hit the ball back with a swing time

of 0.2 seconds. Using its fingers like a human, the throwing robot was able to control the release timing instantaneously and the direction precisely to hit the ball into the strike zone. It was also possible to pitch the ball to any set target point. As the batting robot adjusts the bat trajectory every 1 kHz in accordance with the three-dimensional location data calculated by the active vision systems, the ball can be hit back even if it is a curve ball or just randomly thrown. In this experiment, because the distance between the two robots was short (the laboratory was small), the pitching speed was limited in accordance with the batting swing time. But calculated to the distance between the actual pitcher mound and home base (18.4 meters), in theory it would have been possible to hit the ball at 300 km/h.

Role of the dSPACE System

The role of the dSPACE system was to receive the sensor data, calculate the motion trajectory between the throwing and the batting robots, and forward instructions to the motor driver. A modular approach with an expansion box was used and proved to be an extremely convenient way to create a large-scale system. ■

Dr. Taku Senoo
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Japan



Outlook

In the future, ultra-high-speed robot systems will be used in accumulating and systematizing a range of skills. In our laboratory, we already achieved dexterous high-speed manipulation tasks such as pen spinning, dribbling a small ball between two fingers and catching ultra-small objects by actively using non-contact and unstable states. Controlling these basic skills is expected to lead to the creation of new forms of robot operation involving dynamic motion rather than conventional forms of robotic operation where tasks are performed semi-statically while constantly maintaining a state of contact with the object.

Demo video at
www.dspace.com/goto?cv