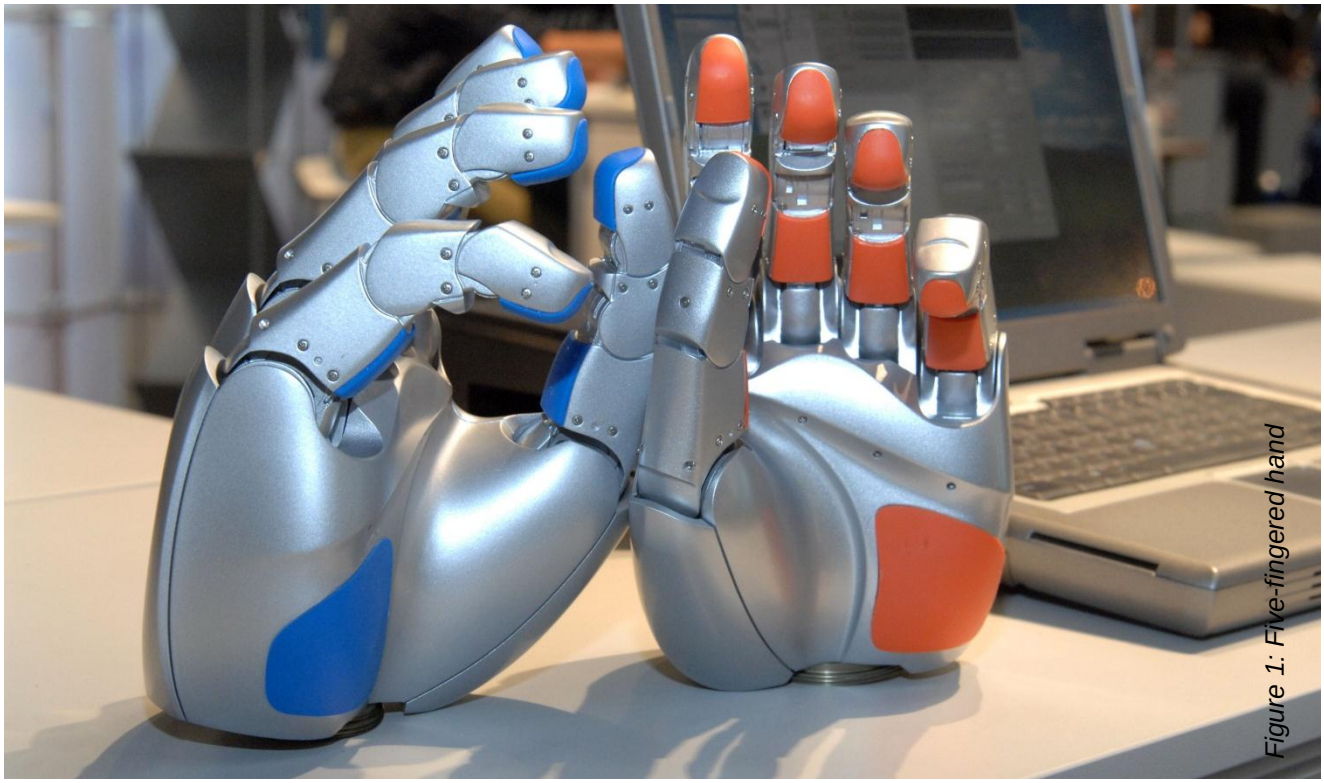

Figure 1: Five-fingered hand

maxon motor Moves Humanoid Robotic Hand.

There has been rapid progress in the development of robotic hands that replicate human movement; delicate grippers with fingers and thumbs are now no longer a vision but a reality. Soon multi-fingered hands will also feature in the daily work environment. Where simple but robust two or three-fingered grippers are currently employed, soon complex five-fingered hands, powered by maxon's brushless DC motors, will also be able to carry out intricate tasks. Significant progress in microelectronics and micromechanics means that multi-fingered hands can now be produced with separately controllable fingers and joints that replicate the human hand. The complex mechanics and control electronics required for this can even be constructed, to a certain extent, using standard commercial components.

The human hand is undoubtedly one of the most universal and complex tools of nature. Researchers have been studying the characteristics and special features of this evolutionary design for years. Now the findings of this research are being used and implemented for the robotic hand of the future. The German Aerospace Centre (DRL) has developed a new robotic hand in conjunction with the Harbin Institute of Technology (HIT). Thanks to micro and precise drive technology, together with high-performance bus technology, this development is setting new standards for sensitive gripper hands that replicate human ones. Compared with its predecessor, the DRL-HIT-Hand I, the new DLR-HIT Hand II has five fingers, each with four joints and three degrees of freedom and is smaller and lighter. Four fingers are required for clasping conical parts, and a thumb is used as an outer support. The mechanical range of movement must be properly controlled and monitored to enable the hand to be used fully. High-performance information channels are essential.

High-speed bus for controlling

The brushless DC motors in the DRL-HIT Hand II are fitted directly into the fingers. This means that particular attention has to be paid to the control processor's information with positioning and operating data. This is the only way that the discrete drive can show all its strengths in situ. Every finger joint is therefore fitted with a self-developed non-contacting angle sensor and a torque sensor. Due to the application, both sensors must resolve very highly. A high-speed bus transmits the data flow. Rapid feedback for comparing target and actual value is crucial for the function of the controller, particularly in precise and delicate applications. Therefore, aside from the data volume, speed of transfer is also vital. The internal real-time 25 Mbps high-

maxon motor
driven by precision

speed bus, developed especially for this application, is based on FGPAs (Field Programmable Gate Arrays). Only three leads are required for the external serial connection of hand and control processor. The actual controls, a signal processor on a PCI insert card, is integrated in a standard PC. A user-friendly interface means that the hand can be controlled at the PC, with all sensor data displayed on the screen. From the very outset, data display, controls and the connection between hand and processor were designed to be practicable, with a view to future use in the industrial environment.

maxon flat motors as drives

Each finger needs several drives that can all be controlled separately. In this instance, 15 brushless DC motors with Hall sensors are used for each hand. maxon motor's EC 20 flat drives meet several key requirements in that they are inexpensive, commercially available products with a high power density in a compact design. The motors, including Hall sensors, create a unit that is only 10.4 mm long with an outer diameter of 21.2 mm. Each motor weighs 15 g. They are mounted with harmonic drive gearheads from the HDUC 05 range, which have the same diameter. The 3 watt motors are available in a 12 or 24 V version and provide maximum torque of 8.04 mNm. Good dynamic behaviour and preloaded ball bearings ensure precise response behaviour of control commands, including changing the direction of rotation. The digital Hall sensors always report the actual position to the controller accurately. The motors idle at 9,300 rpm.

Thanks to compact drive technology with feedback and rapid data transfer per bus technology, the new DLR-HIT Hand II can be controlled very sensitively and precisely. Micromechanics and microelectronics complement each other perfectly. Today, standard components can be used to produce well-designed products which would have been previously unimaginable, even with expensive special developments.

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Application note: 4570 character, 716 words

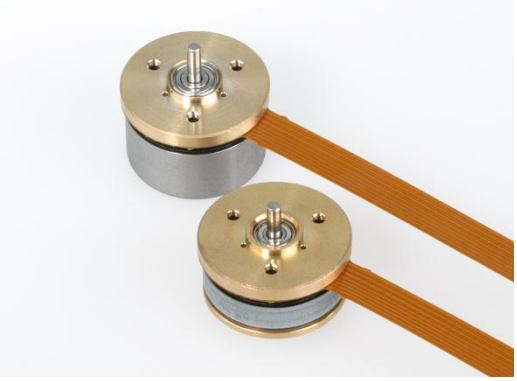

Figure 2: EC flat motor from maxon motor

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