Stiffness Control of Multi-DOF Joint

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We have developed an artificial articulation similar to a wrist joint that has multiple-rotary axes in one joint. The research focuses on controlling the joint stiffness. It inevitably requires a linear elastic actuator similar to a voluntary muscle. So we have previously developed a muscle-like actuator, called ANLES (Actuator with Non-Linear Elastic System) as a core element to compose a mechanical musclo-skeletal system. The parts and the assembling figure are shown in Fig.1. It is a linear actuator but controlled by one DC motor of which torque is transformed into linear force via a super-long lead ball screw. Inversely an external force loaded along the ball screw rod is transformed into a torque that twists a torsion spring. The torsion spring is coiled around the guide-shaft of which diameter is gradually varied to provide an equivalent non-linear elasticity of the spring. The non-linear elasticity is indispensable for ADJ (Antagonistically Driven Joint).

Fig.2 shows a structure of the three DOF wrist joint that is controlled by four ANLES and one DC motor to rotate the central axis. It is the second machine developed last year to downsize its weight and length almost a half compared to the first machine (Fig.3). The weight diminishes from 2.8 kg to 1.3 kg. Some other refinements have been schemed as follows.

(1) The range of stiffness variation became wide.
(2) Some amount of viscosity is added into the ANLES to suppress vibrations caused by the elasticity.

The ADJ developed in this research has the following advantages.

(1) The stiffness characteristics is strictly analyzable and easy to design through designing the shape of the guide-rod.
(2) Compact and all-in-one assembly is achievable.

The experimental results will be shown in the presentation at the workshop.

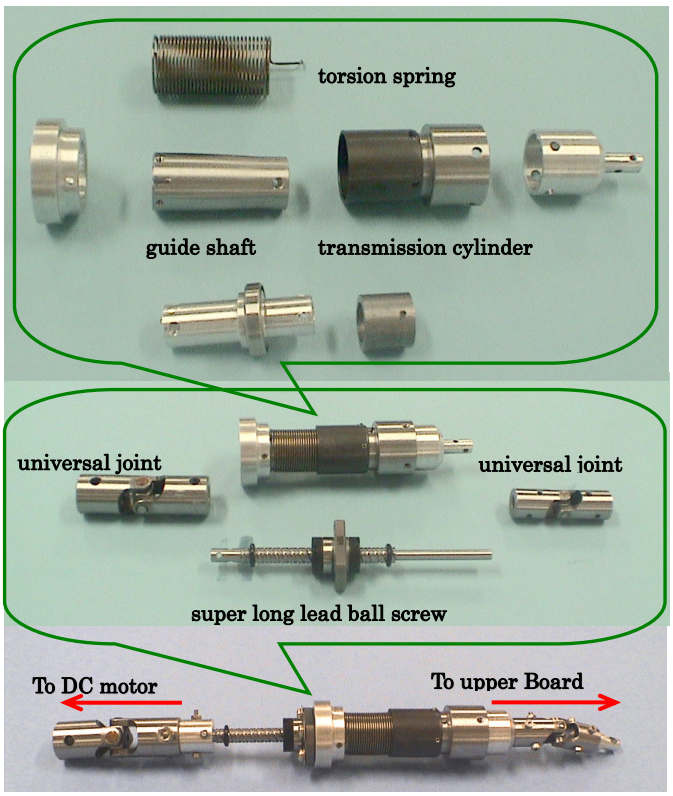

Fig.1 The linear-type ANLES

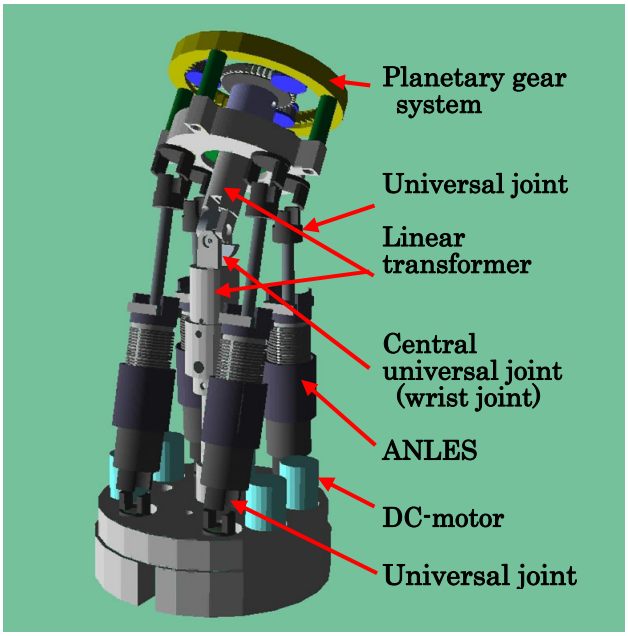

Fig.2 The structure of the second machine

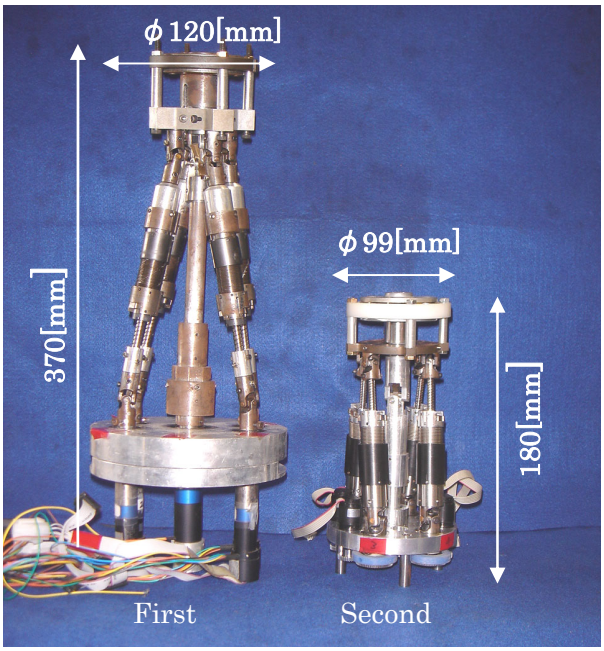

Fig.3 Three DOF wrist joints: the first and the second machines