Fusion hybrid linear actuator: Concept and disturbance resistance evaluation

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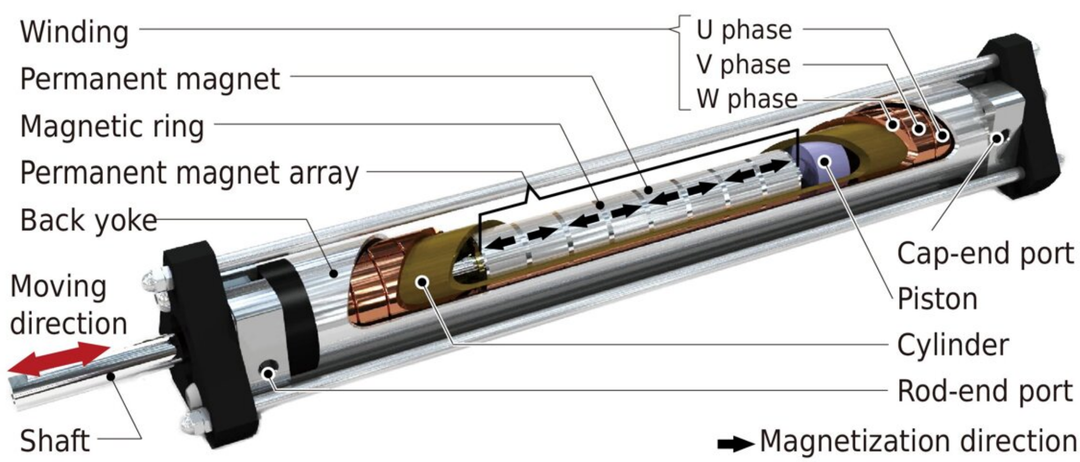
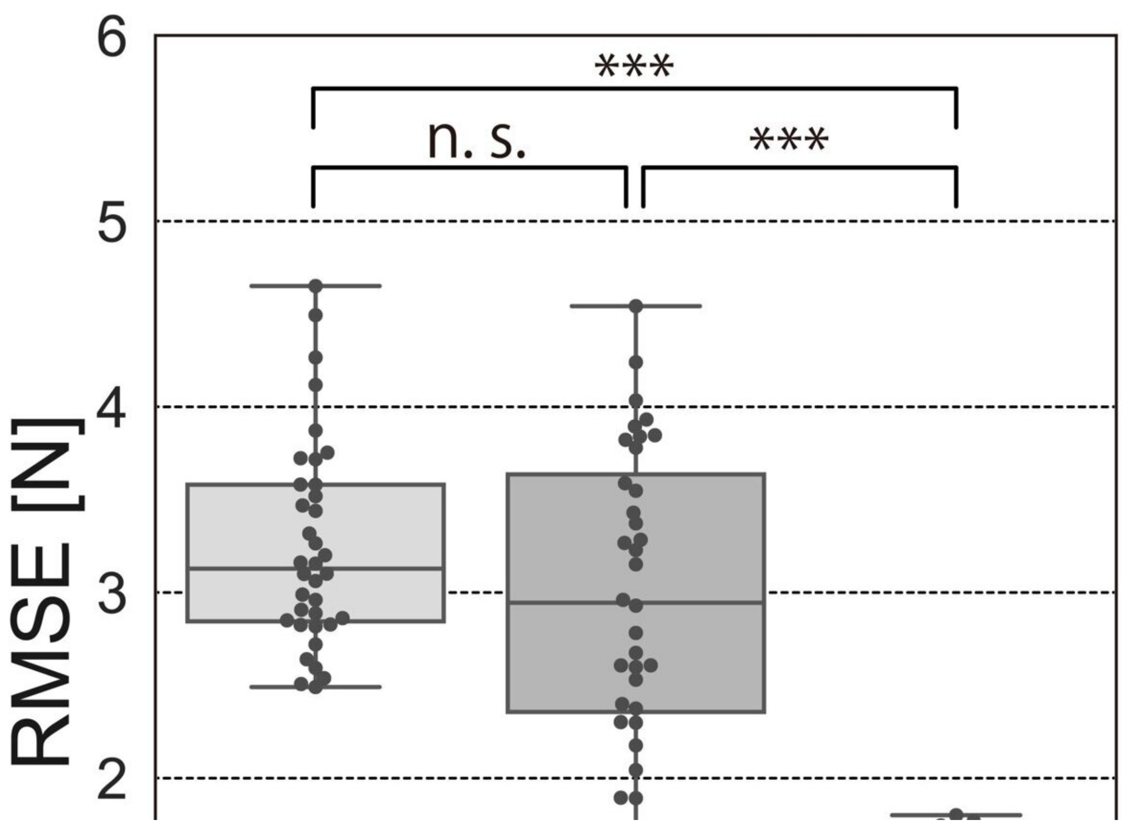


Three-dimensional computer-aided design image of integrated pneumatic-electromagnetic hybrid linear actuator, an example of one realization of the fusion hybrid linear actuator. Note that the part of the model is sectioned. Credit: The University of Electro-Communications

Addressing a fundamental challenge in robotics, Associate Professor Yoshihiro Nakata of The University of Electro-Communications, Japan, and Senior Researcher Tomoyuki Noda from the Brain Information Communication Research Laboratory Group at the Advanced Telecommunications Research Institute International, have developed a pioneering technology to facilitate the integration of hybrid actuation systems. Hybrid actuation, which pairs two actuators operating on different principles to yield superior performance, has been historically difficult to incorporate into robots due to the complexity of its structure.

To tackle this issue, they have conceptualized the "Fusion Hybrid Linear Actuator" (FHLA), a design that combines structures to convert the energy of multiple actuators into force, synthesizing these forces internally as though they originate from a single actuator. Specifically, an actuator merging a pneumatic cylinder and a direct-drive linear motor has been developed based on this design concept, effectively blending the benefits of both systems while reducing their overall footprint.



In the comparison of the root mean square errors of the contact force, three conditions were examined: 1) P-N (Pneumatic Force + No Friction

Compensation) Condition: The base contact force was generated by air pressure. 2) P-P (Pneumatic Force + Friction Compensation by Pneumatic Force) Condition: The base contact force was generated by air pressure, and a controller was designed to compensate for deviations in the contact force caused by kinetic friction using pneumatic force. 3) P-E (Pneumatic Force + Friction Compensation by Electromagnetic Force) Condition (Hybrid Actuation): The base contact force was generated by air pressure, and a controller was designed to compensate for deviations in the contact force caused by kinetic friction using electromagnetic force. The root mean square errors in the P-E condition were found to be significantly smaller than those of the other two conditions. Credit: The University of Electro-Communications

Experimental results have demonstrated that this actuator significantly improves the ability to maintain a constant contact force against disturbances in motion over a wide range of forces, compared to systems using only air or electricity as a power source. This suggests a superior force control performance at the point of contact, offering a significant enhancement over conventional actuators.

In this research, the team not only presented the new concept of FHLA but also discussed its design strategy requirements and structural optimization processes, marking a considerable stride in the field. This breakthrough research has been published in the *IEEE/ASME Transactions on Mechatronics*, presenting a significant step toward more versatile and efficient robotics in the future.

More information: Yoshihiro Nakata et al, Fusion Hybrid Linear Actuator: Concept and Disturbance Resistance Evaluation, *IEEE/ASME Transactions on Mechatronics* (2023). DOI: 10.1109/TMECH.2023.3237725

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