# Development of Bar-shape Nonlinear Series Elastic Actuator

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## INTRODUCTION

Series elastic actuators (SEAs) have gained attention as a human assist device.

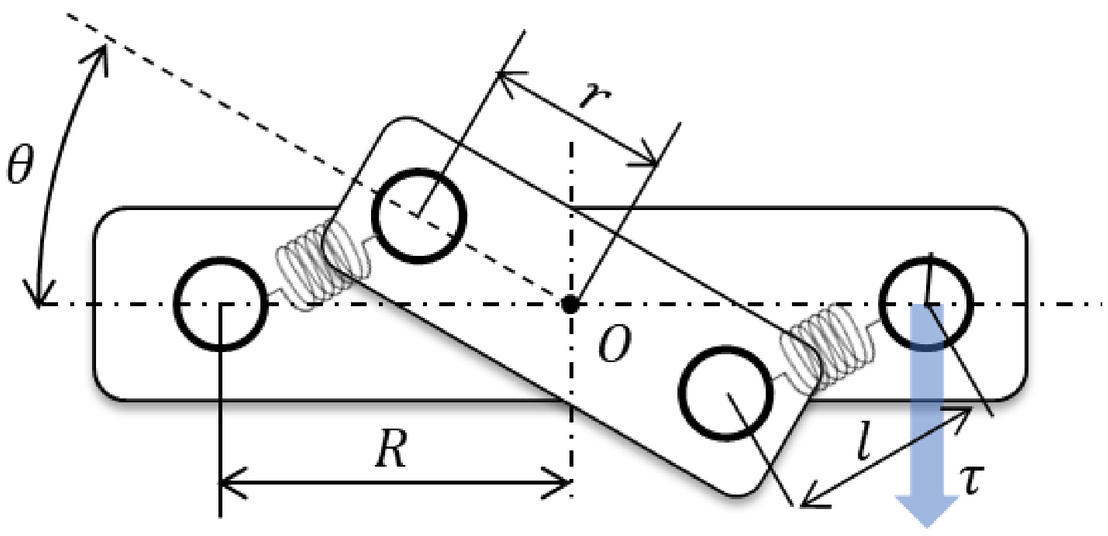
Nonlinear SEAs have possibility to overcome the limit of conventional SEAs, but existing actuators have some restrictions in design.

**Bar-shape nonlinear SEA**

- High torque accuracy with kinematic model
- Less design restrictions when attached to human body joints

## KINEMATIC MODEL

The spring unit consists of two bars which are coaxial rotating around point $O$, and springs.
The stiffness is increases with deflection angle $\theta$.




The length of springs $l$ changes based on cosine law as:

$$l(\theta) = \sqrt{r^2 + R^2 - 2rR\cos\theta} \qquad (1)$$

The output torque of bars $\tau$ can be calculated by:

$$\tau(\theta) = nrRk\frac{l(\theta) - l_o}{l(\theta)}\sin\theta \qquad (2)$$

$n$ : Number of springs

$k$ : Stiffness of springs

$l_o$ : Rest length of springs

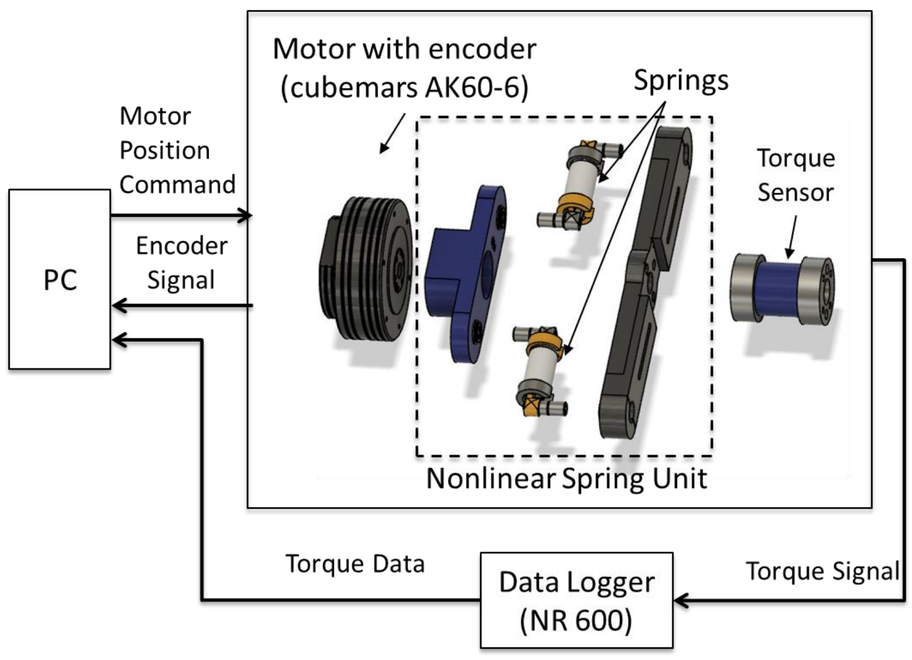
## STATIC EXPERIMENT

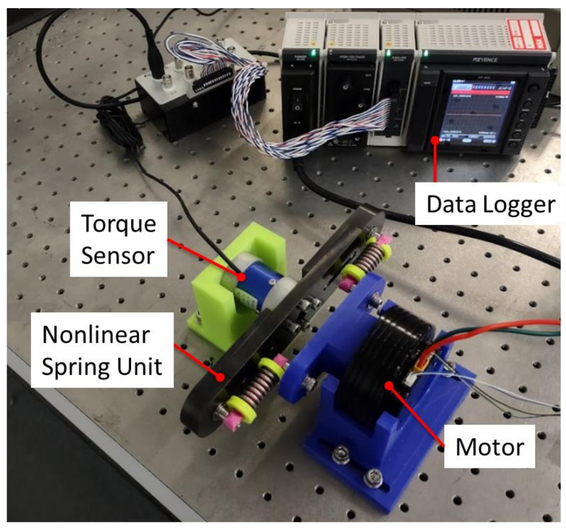
**Purpose**

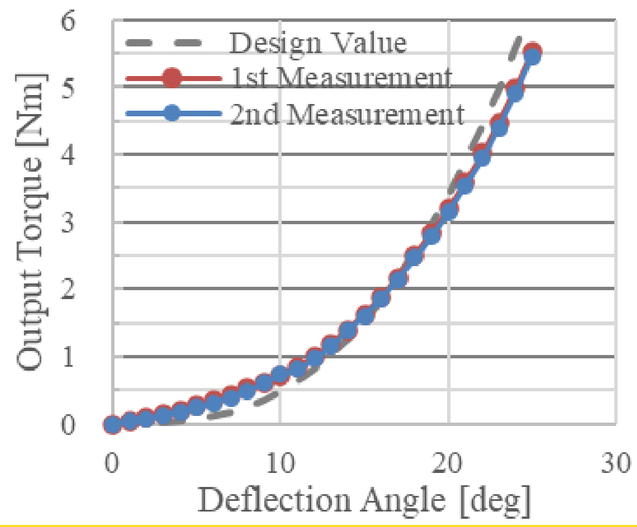
Verifying the torque accuracy of the actuator with the kinematic model

**Result**

- The stiffness was changed as designed
- RMS error of torque was 0.3 Nm
- The error is attributed to spring pretension, unexpected deformation of components.

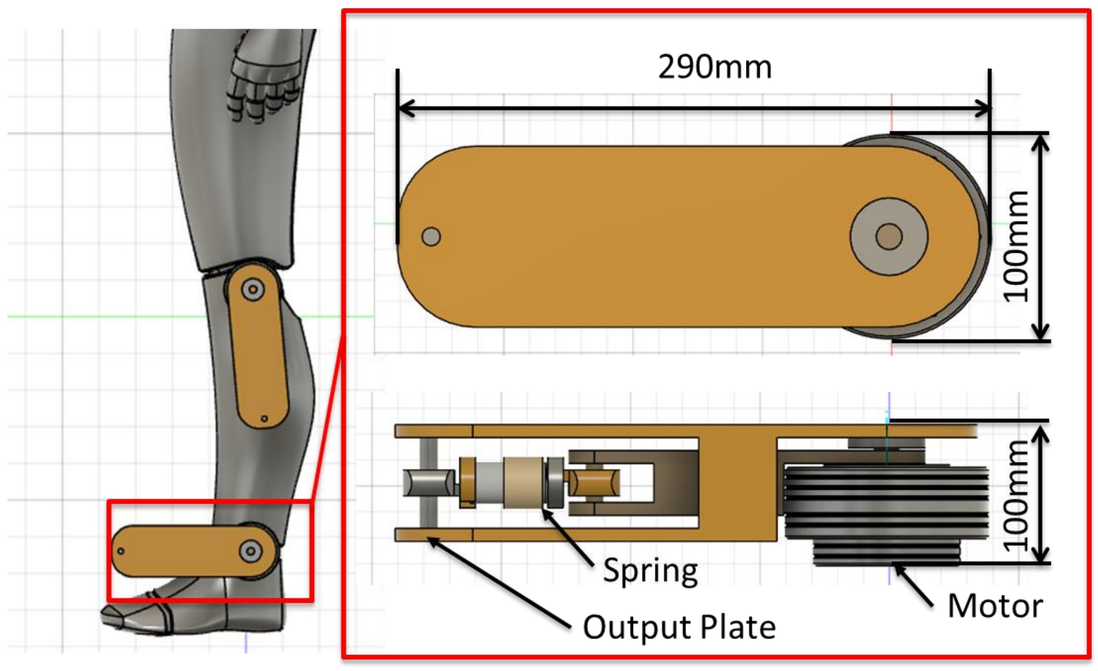



## FUTURE WORKS

We are designing below actuator.




**Application**

Posture control assist device for people at high risk of slips and trips, falls; active elders and workers, etc.