Concept Design of Multi-winding type Gravity Compensation Mechanism for High Torque Compensation

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Research Background

- An increase in the population of aged people ↑
  : Decreased physical function in the elderly
  – reducing walking speed
  – Increasing in falls

→ Wearable robot is required to improve gait function of the elderly

- Bulky
- Rely on upper limb

- Passive
- No muscle support

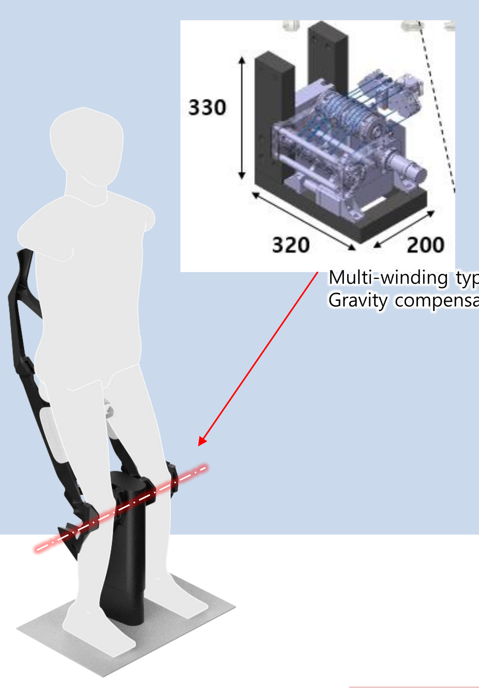
- Heavy, expensive
- Discomfortable (uncomfortable-to-wear)

▶ **Research objective**:
Development of Gravity Compensation Mechanism for High Torque Compensation to be used in wearable devices

Research Topics

Gravity compensation mechanism

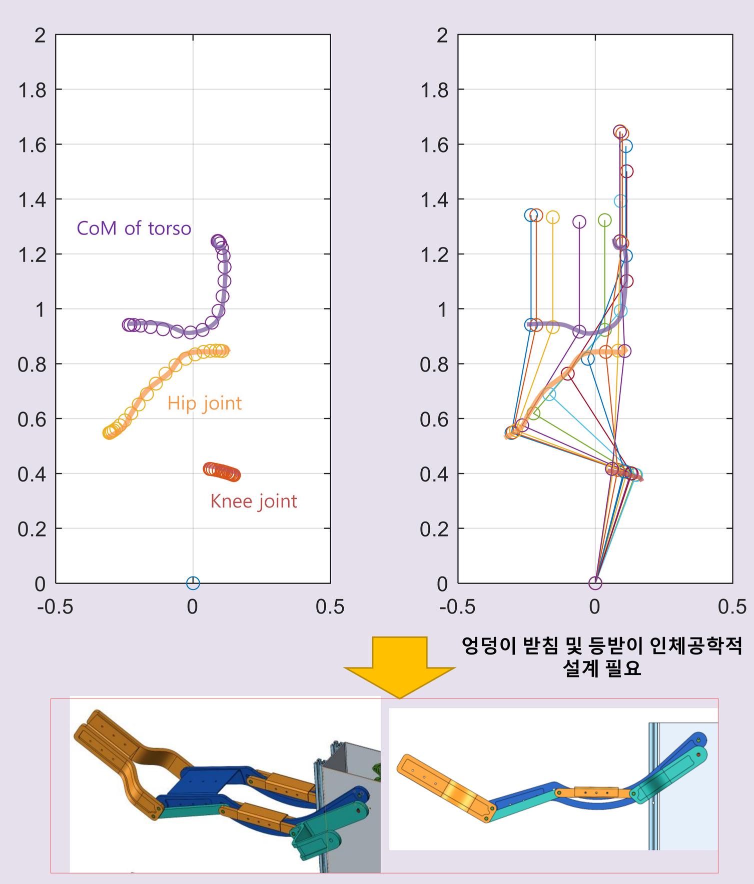
[Characteristics of SMA spring]

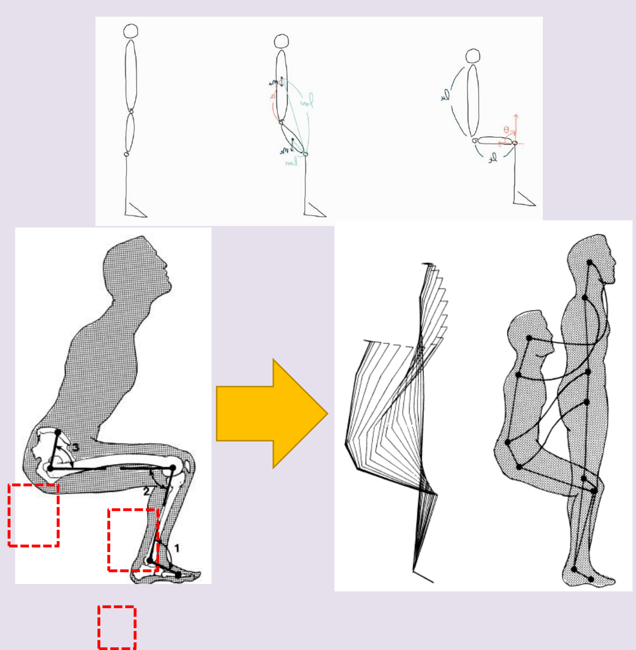


Many robots are being developed to help people with weak bodies, such as the disabled and the elderly. It is very important to help disabled people with sit-to-stand function. In order to handle the weight of a person, a large torque is applied to the joint, and we must overcome this by using active or passive actuators. According to the demand for small, light and invisible assistive devices, it is necessary to develop a wearable type robot to satisfy the demand and therefore, it is essential to use a small motor using a tendon driven mechanism. Therefore, the size of the motor can be reduced, and the development of an actuator is not directly attached to the joint is also required.

- **Essential requirements of GCM:**
  – trajectory considering the change in the relative joint rotation angle of the ankle, knee, and hip
  - ankle: Δ10° (100°~110°)
  - knee: Δ80° (95°~175°)
  - hip: Δ70° (110°~180°)

Simlation of sit to stand motion

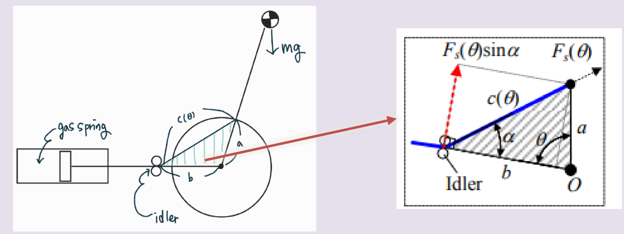




[Fabric muscle fabrication process]

Multi-winding type gravity compensation mechanism

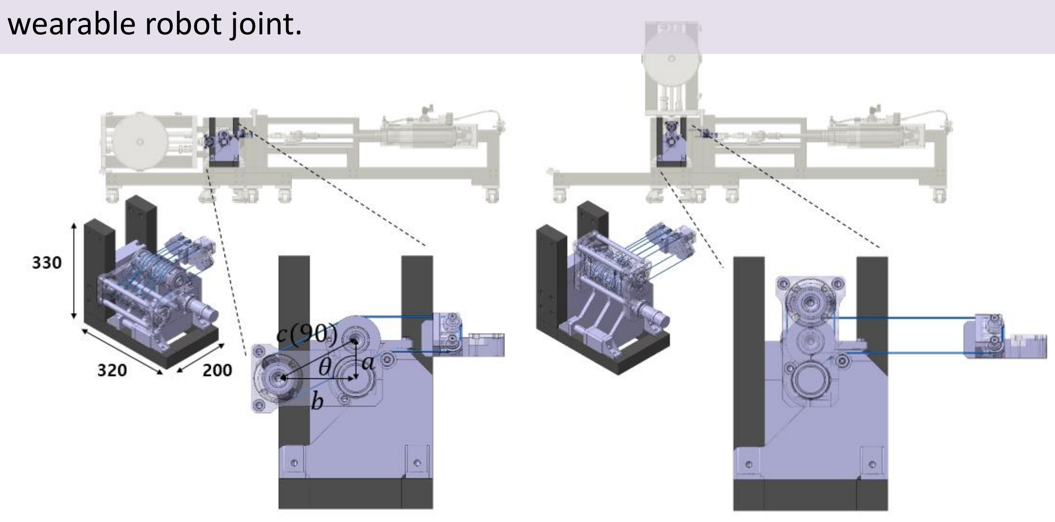
❖ **gravity compensation mechanism**



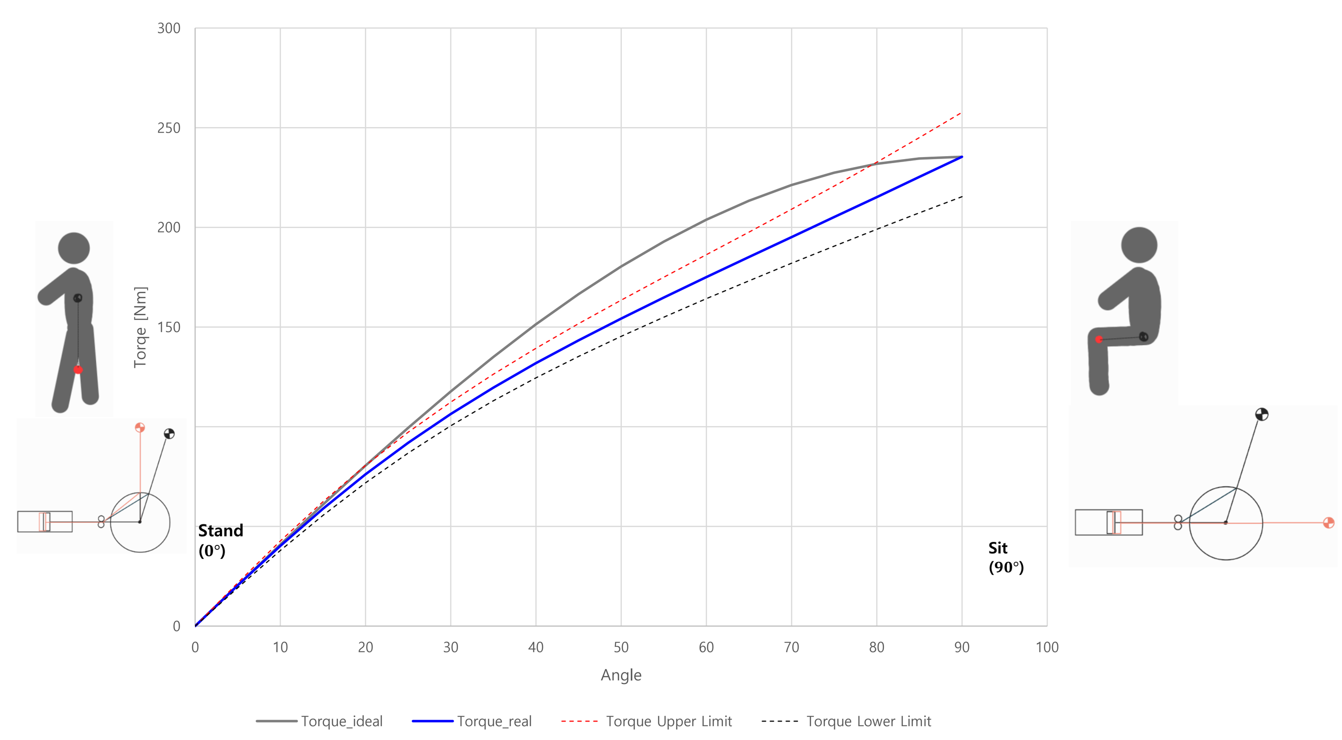
$$F_s = F_0 + k\Delta x(\theta)$$

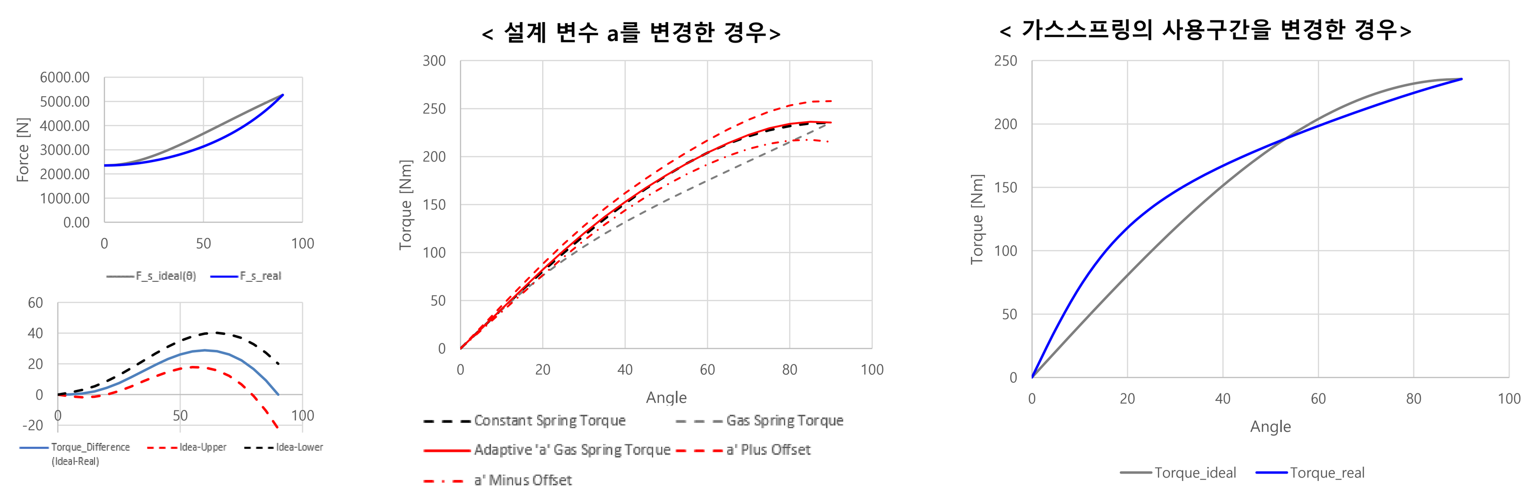
$$x(\theta) = f(c(\theta)), \quad k = \frac{l_c mg}{ab}$$

Gravity compensation mechanisms using the Hooke's law have been mainly developed and energy is stored in the spring as much as the displacement of the spring, and torque is compensated using it. Gravity compensation mechanisms have been developed through many studies, but they are still large and can compensate for small torques. In addition, the compensation error through experiment is quite large. We propose a multi-winding type gravity compensation mechanism to compensate for the large torque of the wearable robot joint.



Experiment





[Coclusion]

The multi-winding type gravity compensation mechanism showed the possibility of torque compensation in the test bed. We plan to make it compact and lightweight so that joint torque compensation of wearable devices can be performed efficiently in the future.

Future Works

- Multi-winding type gravity compensation mechanism will be compact and lightweight so that joint torque compensation of wearable devices can be performed efficiently
- An experiment to verify the effect of a GCM assisting an ankle during gate cycle
- Usability evaluation of a GCM for supporting ankle muscle targeting the elderly in a walking environment

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