# Development of the Wearable Device for Measuring Finger Joint Angle

The measurement of finger movements using wearable devices have the potential to be used in various applications such as human-machine interface (HMI) and rehabilitation. However, wearable measurements using optical fibers and conductive inks, which are currently the mainstream, have the feature that the angle output by the sensor depends on the size and shape of the finger. Therefore, every time the measurer changes, time-consuming calibration is necessary to match the actual joint angle with the sensor output. In case a person with a hand disease cannot perform sufficient calibration, the sensitivity of measurement can be deteriorated and this prevents the measurements with high precision. Therefore, we research aiming to develop a wearable device that can measure the joints angle of fingers without depending on the dimension of the finger.

As a method, the joint angle can be estimated by overlapping the four tendons on the finger at regular intervals and measuring the displacement of them (Fig. 1). By utilizing the difference in the radius of rotation them at the joint part, the joint angle can be measured without depending on the dimension of the finger. By pinching layered belts made of soft polyvinyl chloride (PVC) between the tendons, they bend flexibly even when the fingers have a large curvature, and the intervals between the tendons are kept constant. In order to show the validity of this method, we developed a model miming the motion of flexion and extension of the finger by the serial link mechanism (Fig. 2). An experiment was conducted by placing tendons and belts on the model, and it showed that the proposed method can measure the joint angle with sufficient accuracy. In the next work, we will develop a glove-type device which can measure the finger joint angle based on the proposed method and knowledge obtained from the study so far.

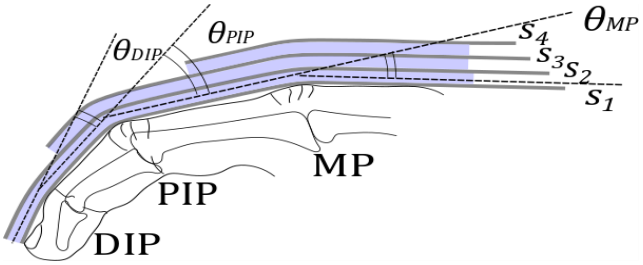


**Figure 1.** The configuration of tendons and belts on the finger. From the tip of the finger, finger joints are called DIP joint (Distal Interphalangeal joint), PIP joint (Proximal Interphalangeal joint), and MP joint (Metacarpophalangeal joint). From surface of the finger, the first and second threads are tensioned from on the nail, the third tendon is between from the DIP joint and the PIP joint, and the fourth tendon is from between the PIP joint and the MP joint. This configuration enables to measure each joint angle at the same time.

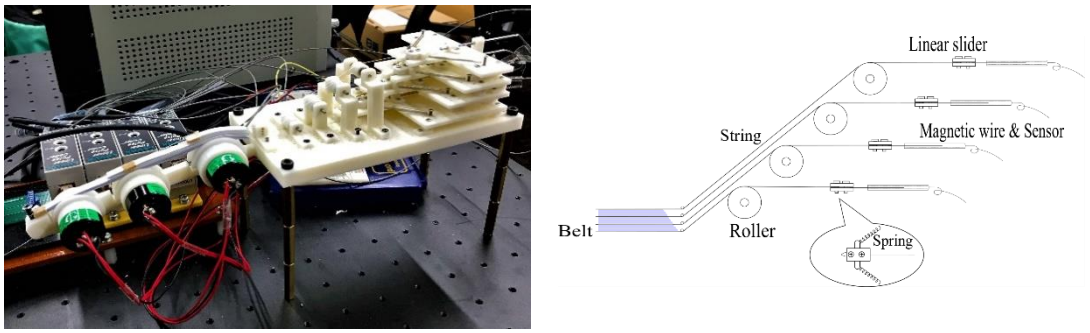


**Figure 2.** (Left figure) A model of the finger of the serial link mechanism used in the experiment. A potentiometer was incorporated in each joint to measure the ground truth of the joint angle. (Right figure) The pass of the tendons. Each tendon is connected to a linear slider via a roller. The linear slider has a role of connecting the tendon and the magnetic wire, and the displacement of the magnetic wire is measured by a sensor.

***Keywords***: data glove, wearable device, finger joint angle