

Intent detection and somatosensory feedback

#01: Introduction: Human-Machine Interfaces, esp. in Reha- and Assistive Robotics

Claudio CASTELLINI, Sabine THÜRAUF

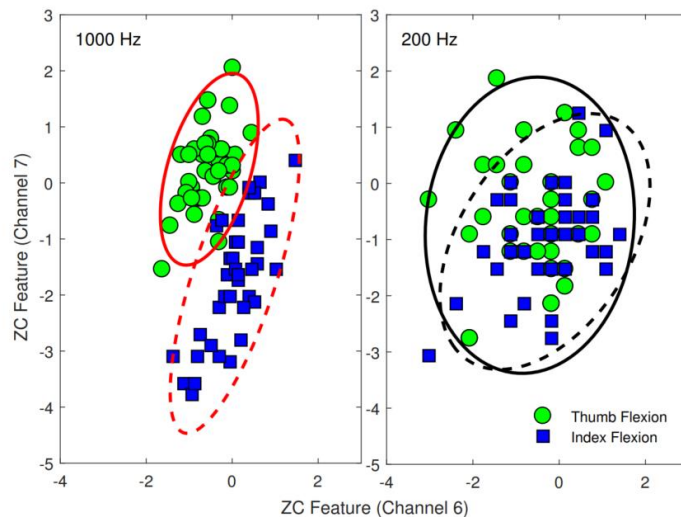


Figure 2. Differences in EMG patterns between using: (left) a 1000 Hz sampling rate; and (right) a 200 Hz sampling rate. ZC features are extracted from two different EMG channels (6 and 7) during thumb flexion (green circle markers and solid lines) and index flexion (blue square markers and dashed lines). Samples are from Subject 1 of Database 3.

EMG patterns related to two actions. Reproduced from Angkoon Phinyomark, Rami N. Khushaba and Erik Scheme, *Feature Extraction and Selection for Myoelectric Control Based on Wearable EMG Sensors*, MDPI Sensors 2018, 18, 1615

The rubber hand illusion. See Botvinick M, Cohen J., *Rubber hands 'feel' touch that eyes see*. Nature. 1998 Feb 19;391(6669):756. doi: 10.1038/35784. PMID: 9486643.



Intent detection and somatosensory feedback

Our journey – I want to drink!



<https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-5386178/>

Our journey – I want to drink!

Find the mug
Track the mug
Perform trajectory planning
Move hand to the mug
Perform grasp planning
Open the hand
Orient the hand properly
Close the hand
Adjust force
Perform trajectory planning
Move mug to mouth
Drink



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Our journey – I want to drink!

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Orient the hand properly

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Adjust force

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Move mug to mouth

Drink

visual feedback

visual feedback

internal process

interaction with real world & feedback

internal process

interaction with real world & feedback

interaction with real world & feedback

interaction with real world & feedback

interaction with real world & feedback

internal process

interaction with real world & feedback

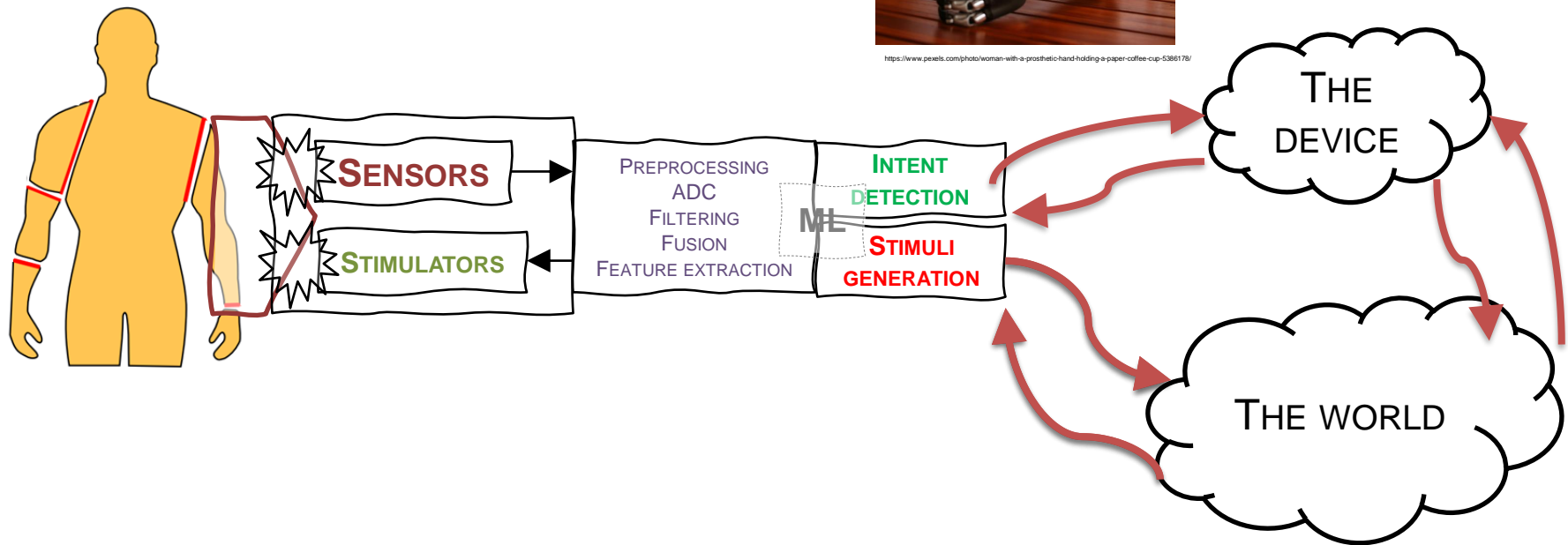
interaction with real world & feedback

Intent detection and somatosensory feedback

HMIs for the disabled

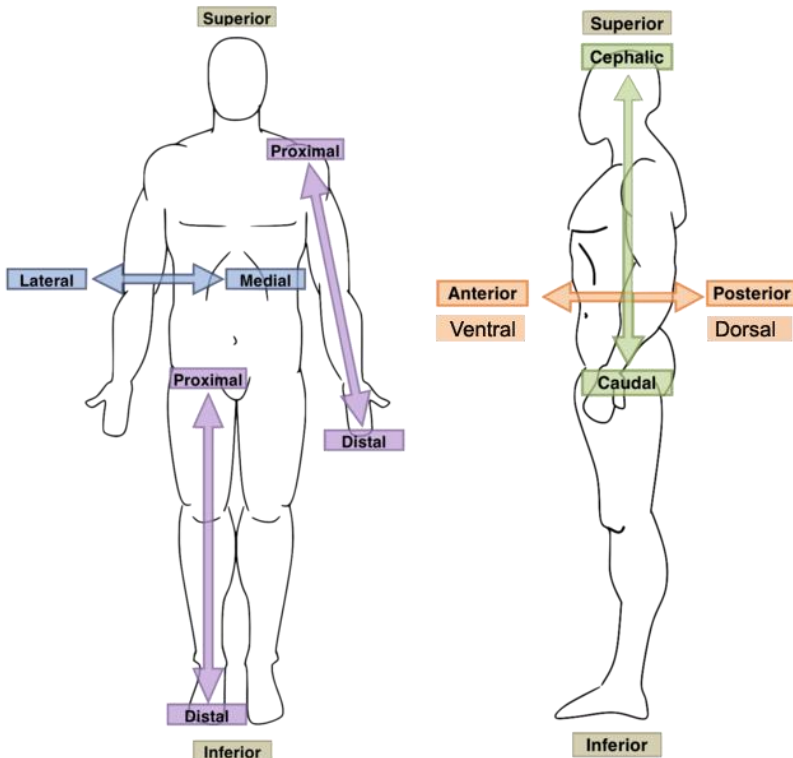


<https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-5386178/>



Terminology

- anatomical position, orientation, directions and planes



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Intent detection and somatosensory feedback

Terminology

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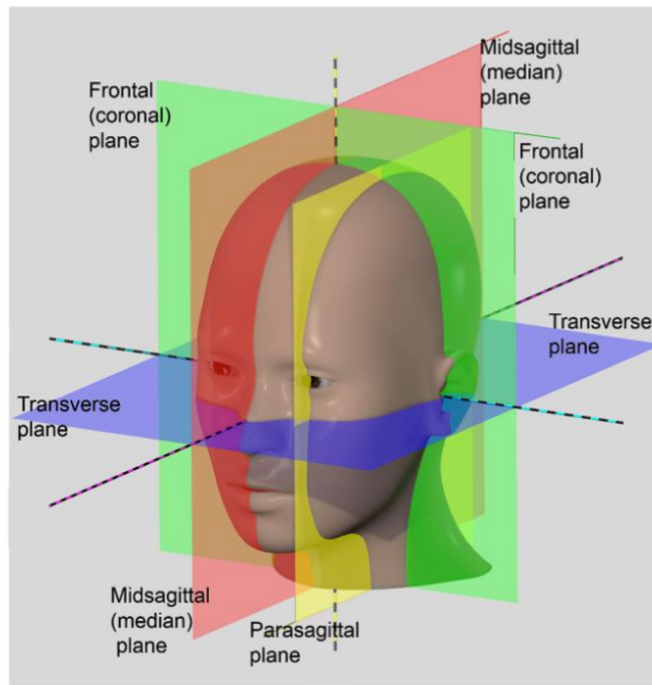


Figure 1-2. The different sectional planes used to expose internal structures.

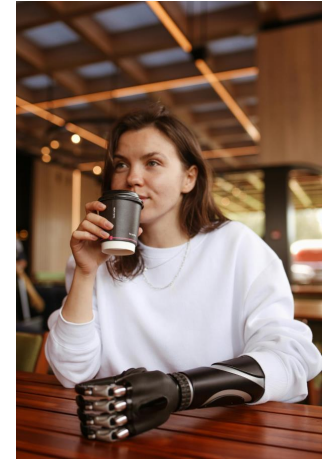
<https://courses.lumenlearning.com/ap1x94x1>



<https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-5386178/>

Terminology

- anatomy of the torso, bones
- shoulder
 - forms the *pectoral girdle*
- consists of two bones
 - the *scapula* (shoulder blade)
 - the *clavicle* (collar bone)



<https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-5386178/>

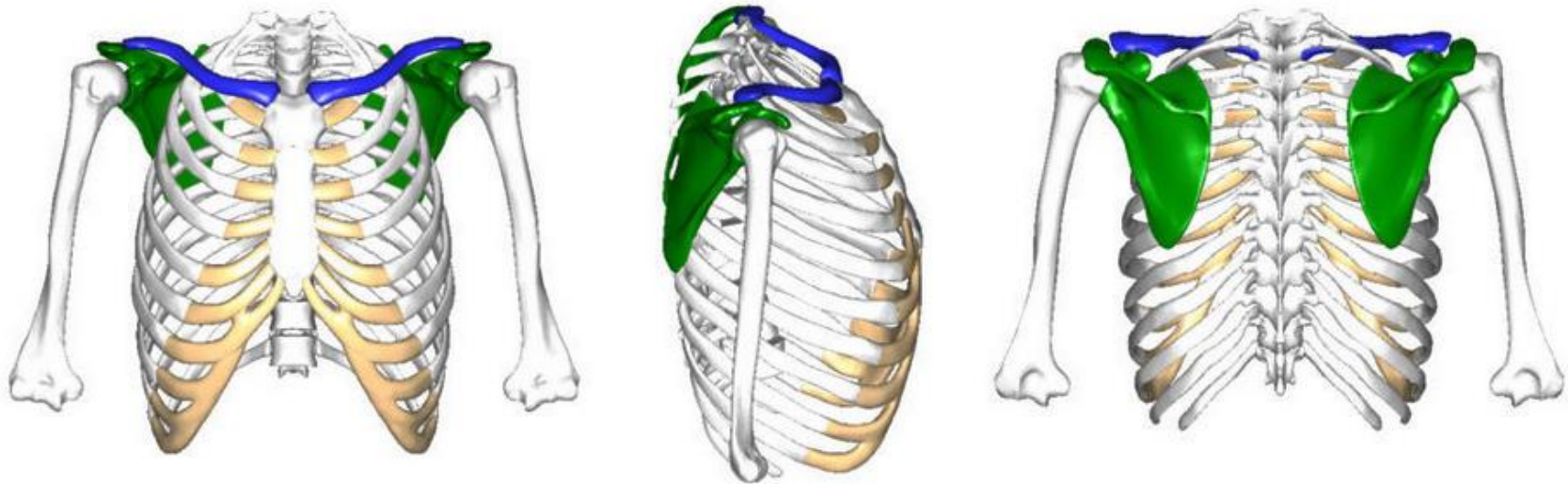
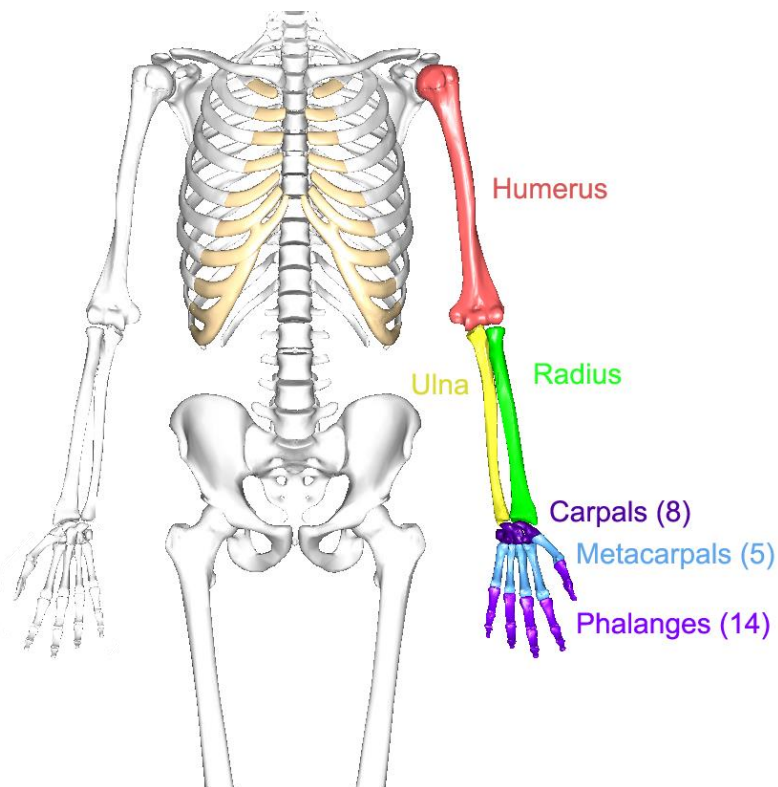


Figure 7-5. The pectoral girdle. The scapulae are in green and the clavicles are in blue.

Terminology

- anatomy of the upper limb, bones



<https://courses.lumenlearning.com/ap1x94x1>



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Intent detection and somatosensory feedback

Terminology

- anatomy of the upper limb, bones

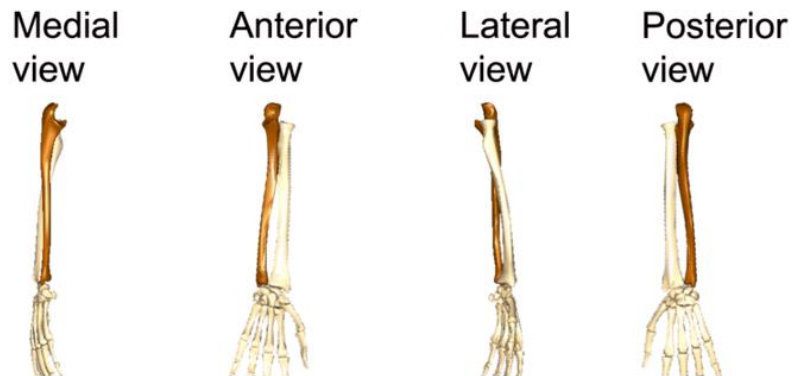


Figure 7-10. The left ulna (In brown) and its major markings and processes.

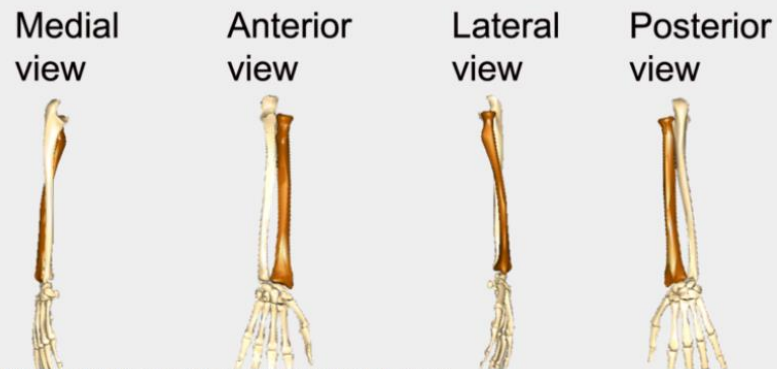


Figure 7-11. The left radius (In brown) and its major markings and processes.

<https://courses.lumenlearning.com/ap1x94x1>



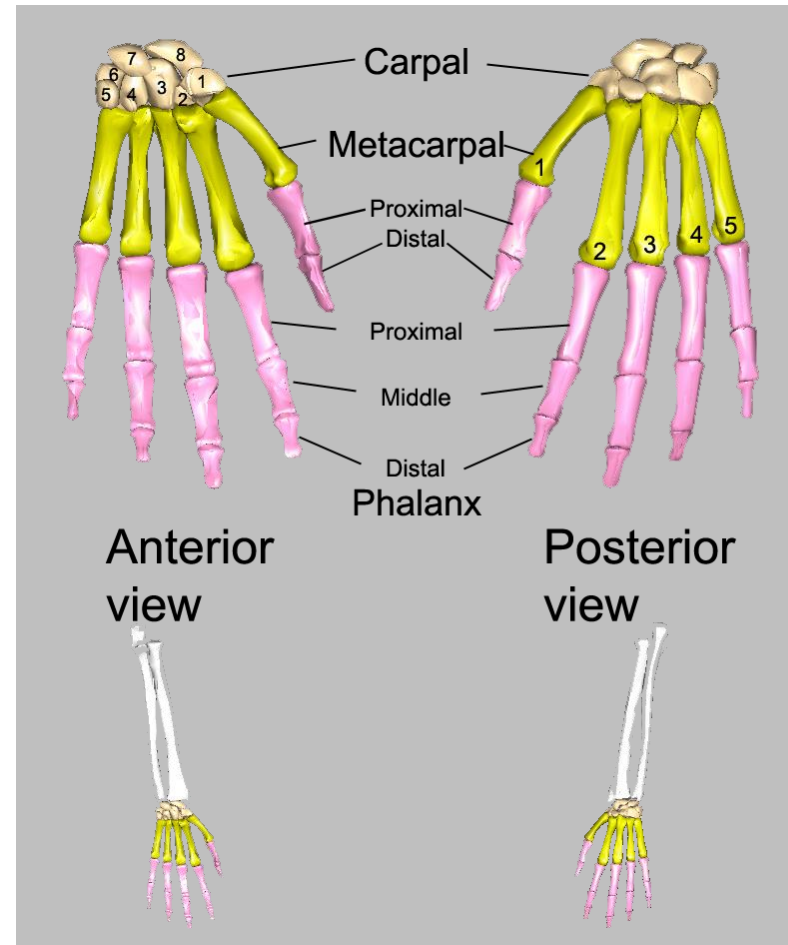
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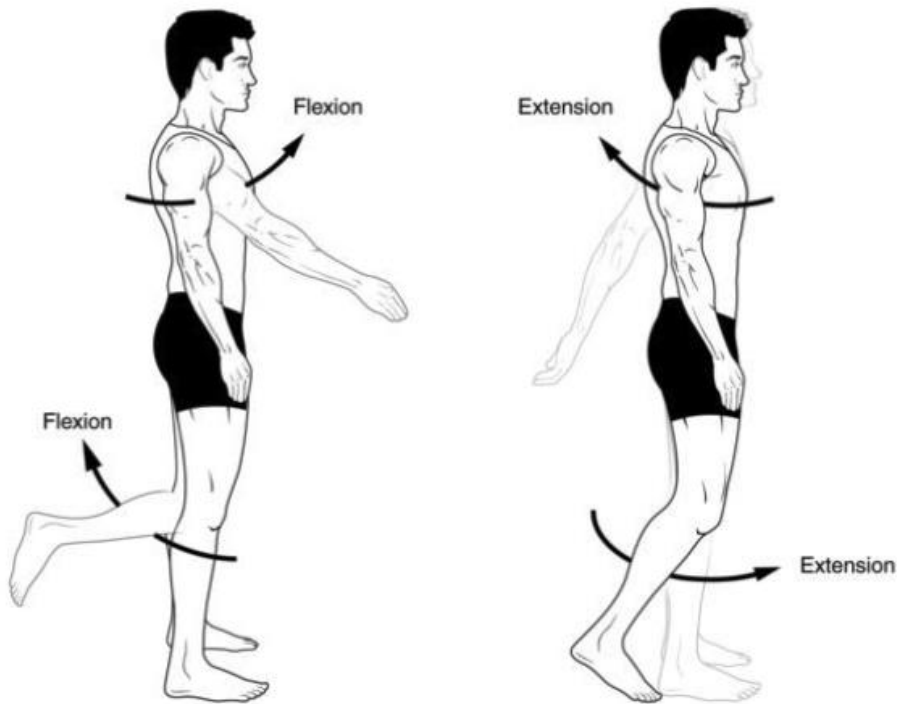


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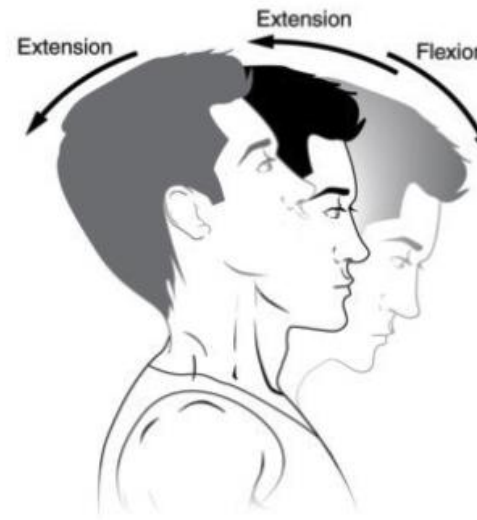
Intent detection and somatosensory feedback

Terminology

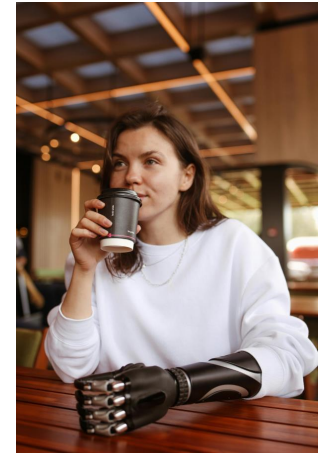
- anatomy, movements relative to the body



(a) and (b) Angular movements: flexion and extension at the shoulder and knees



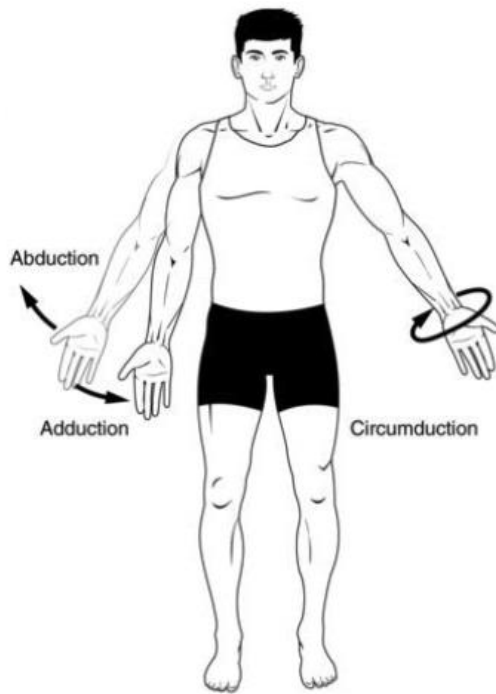
(c) Angular movements: flexion and extension of the neck



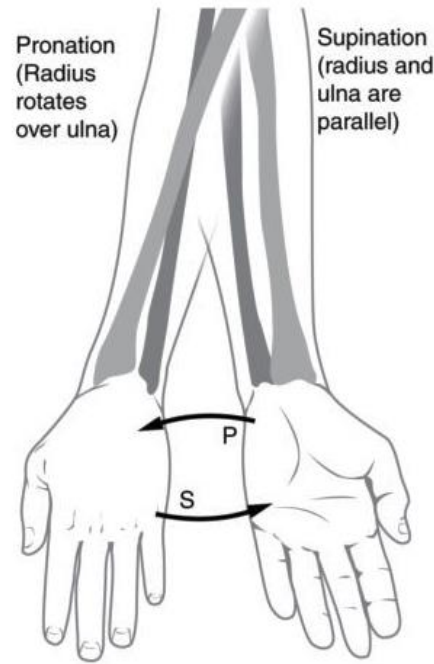
<https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-5386178/>

Terminology

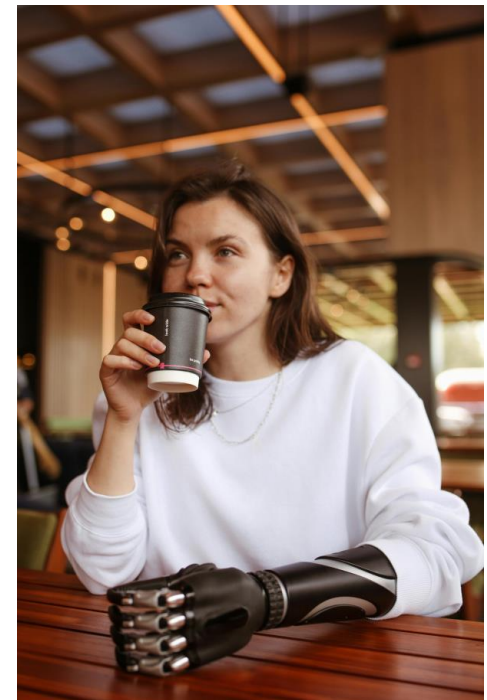
- anatomy of the upper limb, movements



(e) Angular movements: abduction, adduction, and circumduction of the upper limb at the shoulder



(g) Pronation (P) and supination (S)

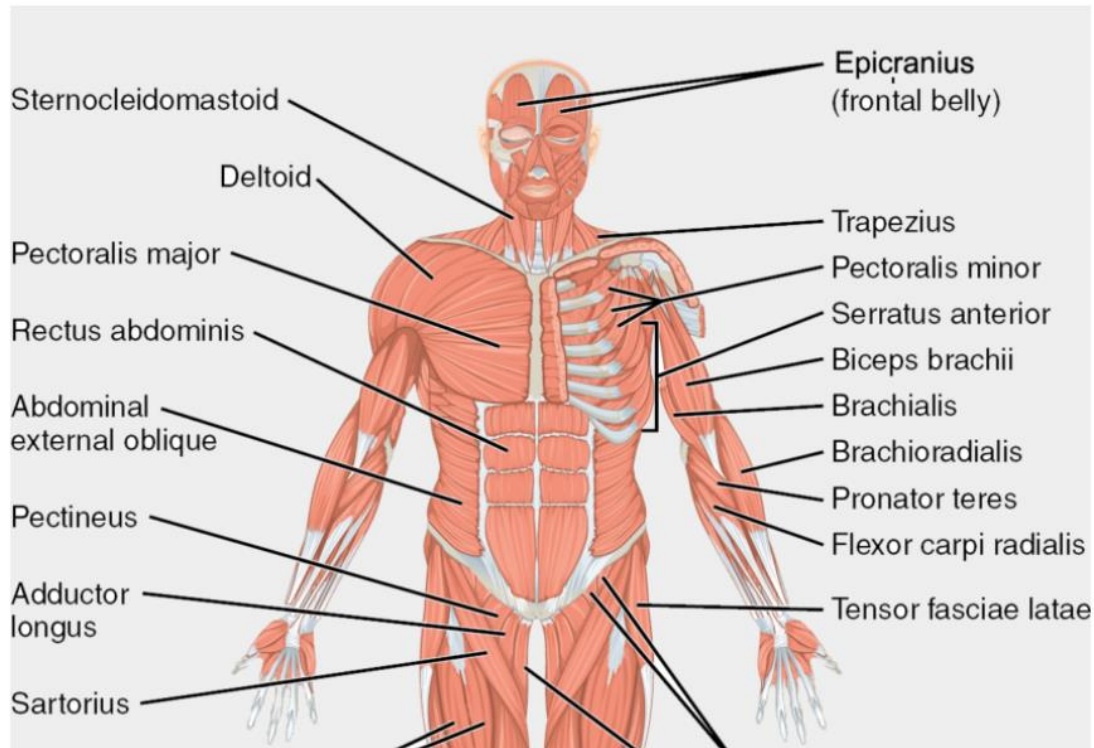


<https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-5386178/>

Intent detection and somatosensory feedback

Terminology

- anatomy, muscles
 - shoulder
 - operated by a complex set of muscles, of which these are of interest to us:
 - *M. Trapezius*
 - *M. Deltoideus*

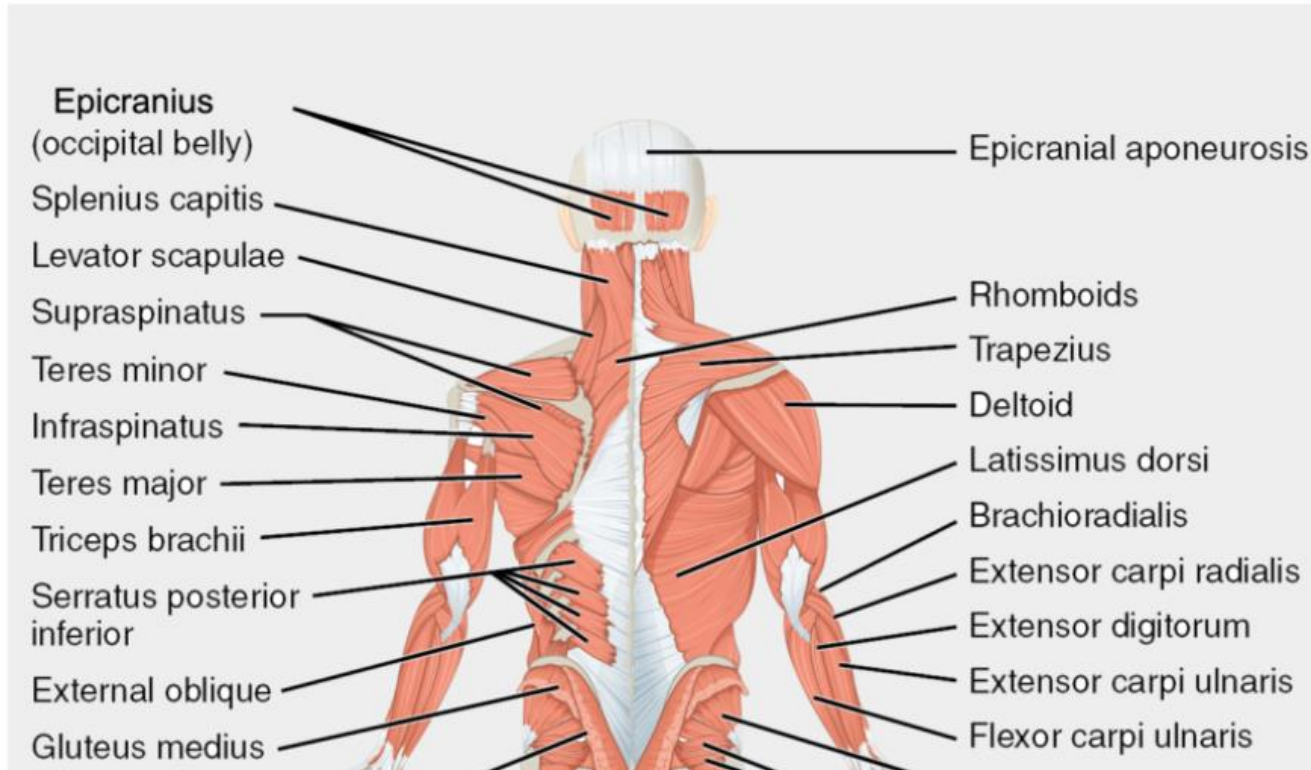


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Intent detection and somatosensory feedback

Terminology

- anatomy of the upper limb, muscles
- shoulder
 - operated by a complex set of muscles, of which these are of interest to us:
- *M. Trapezius*
- *M. Deltoideus*



<https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-5386178/>

Terminology

- anatomy of the upper limb, muscles



<https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-5386178/>

- upper arm
 - *M. Biceps Brachii*
 - *M. Triceps Brachii*
 - *M. Brachialis*

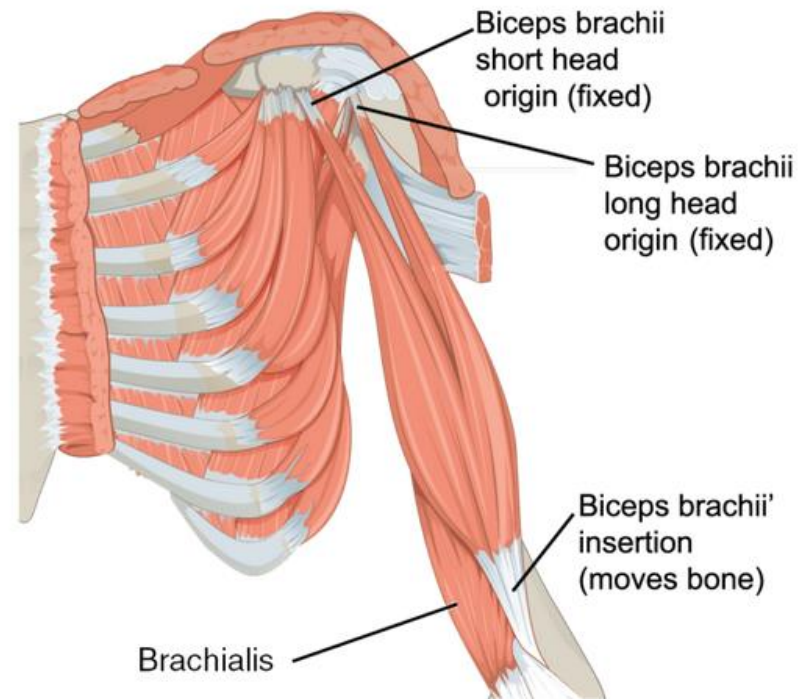
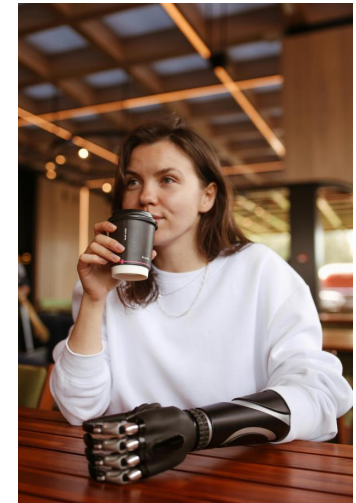


Figure 9-3. The muscles of the arm.

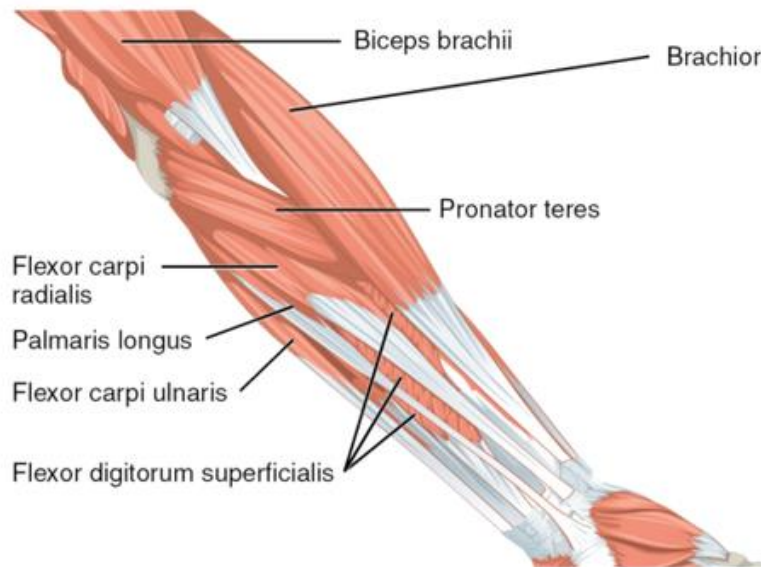
Intent detection and somatosensory feedback

Terminology

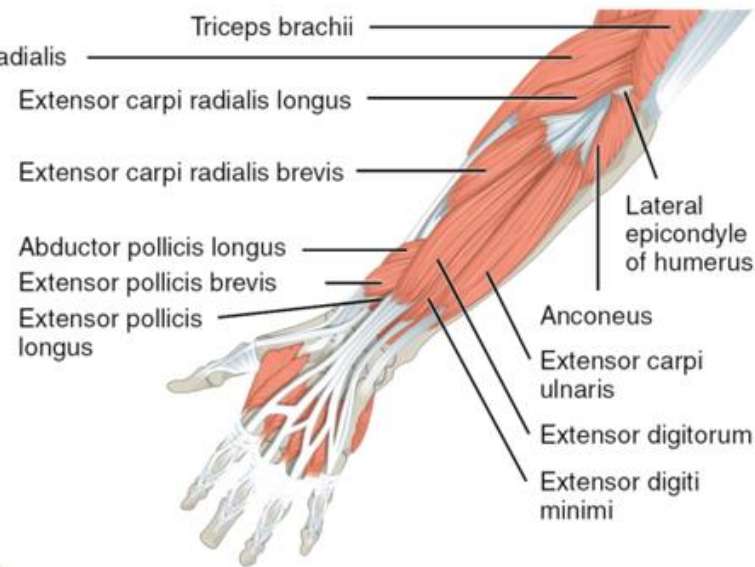
- anatomy of the upper limb, muscles
- lower arm (forearm or *antebrachium*)
 - *M. Flexor Digitorum Superficialis*
 - *M. Extensor Digitorum*
 - *M. Brachioradialis*
 - *M. Pronator Teres*



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Left forearm superficial muscles (palmar view)

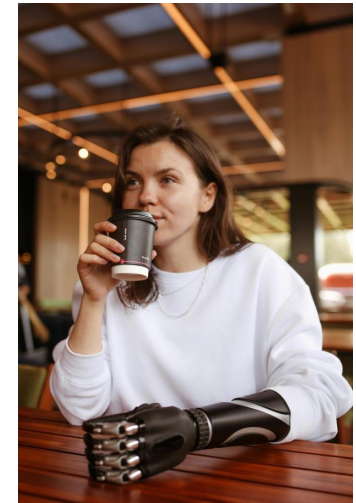


Left forearm superficial muscles (dorsal view)

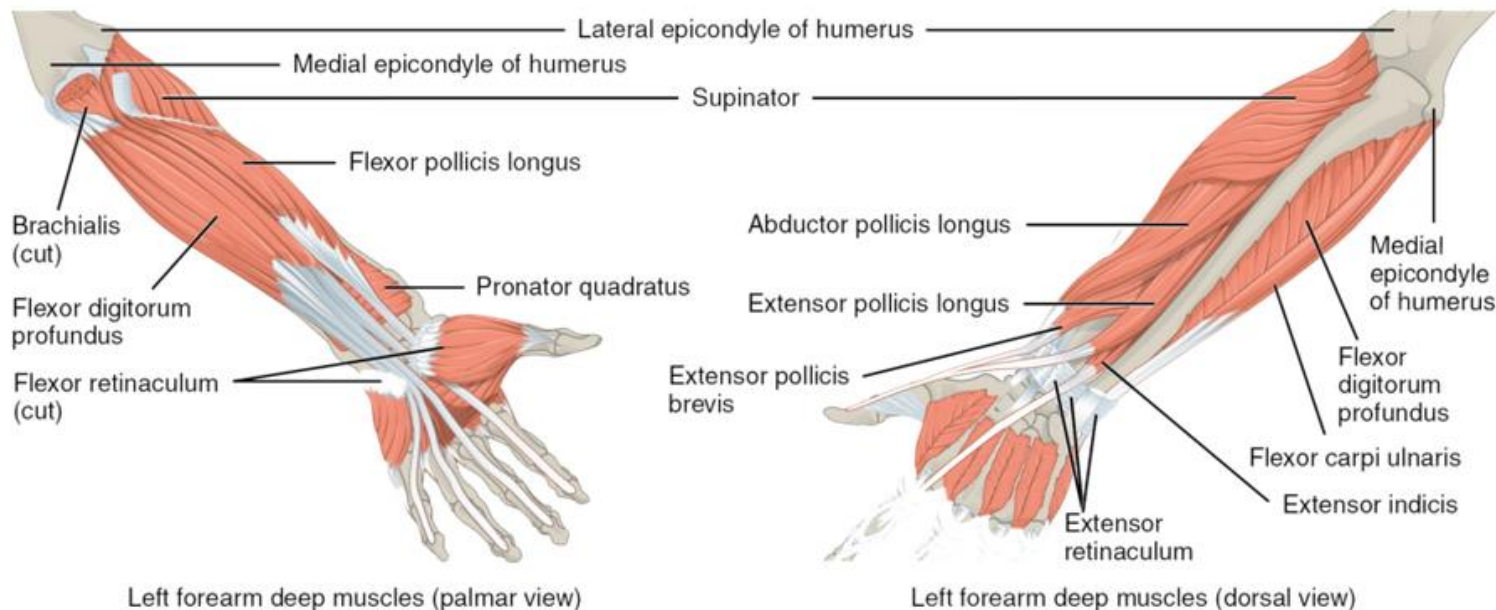
Intent detection and somatosensory feedback

Terminology

- anatomy of the upper limb, muscles
- lower arm (forearm or *antebrachium*)
 - *M. Flexor Digitorum Superficialis*
 - *M. Extensor Digitorum*
 - *M. Brachioradialis*
 - *M. Pronator Teres*



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Intent detection and somatosensory feedback

Terminology

- anatomy of the upper limb, muscles
- Flexor
 - actuates the flexion of wrist / fingers
- Extensor
 - actuates the extension of wrist / fingers
- Flexors and extensors operate, too, as a agonist / antagonist pair
 - helping control the stiffness of wrist and fingers
- Brachioradialis and Pronator operate the pronation / supination of the wrist
 - they operate close to the bones, so
 - their activity remains mostly deep

- lower arm (forearm or *antebrachium*)
 - *M. Flexor Digitorum Superficialis*
 - *M. Extensor Digitorum*
 - *M. Brachioradialis*
 - *M. Pronator Teres*

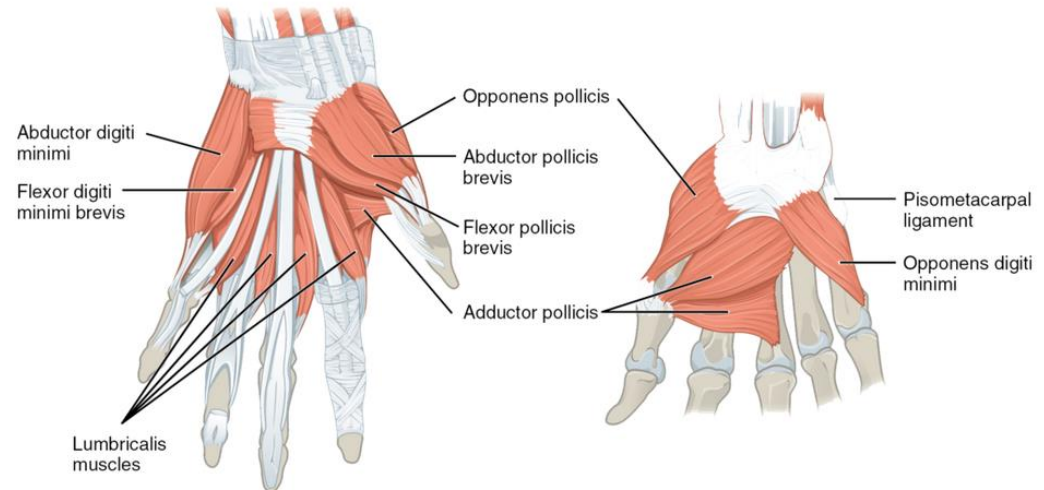


Terminology

- anatomy of the upper limb, muscles
- hand – extremely complex
 - *M. Flexor Pollicis Brevis*
 - *M. Abductor Pollicis Brevis*
 - *M. Palmar / Dorsal Interossei*

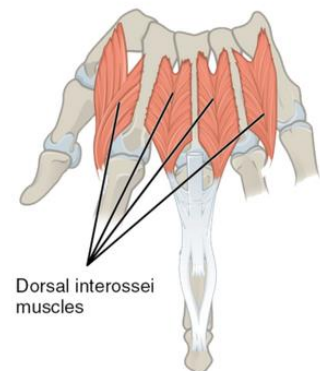
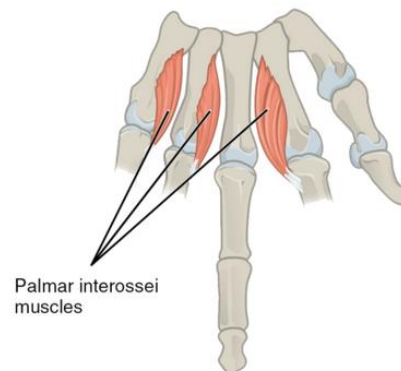


<https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-6386178/>



Superficial muscles of left hand (palmar)

Deep muscles of left hand: (dorsal view)

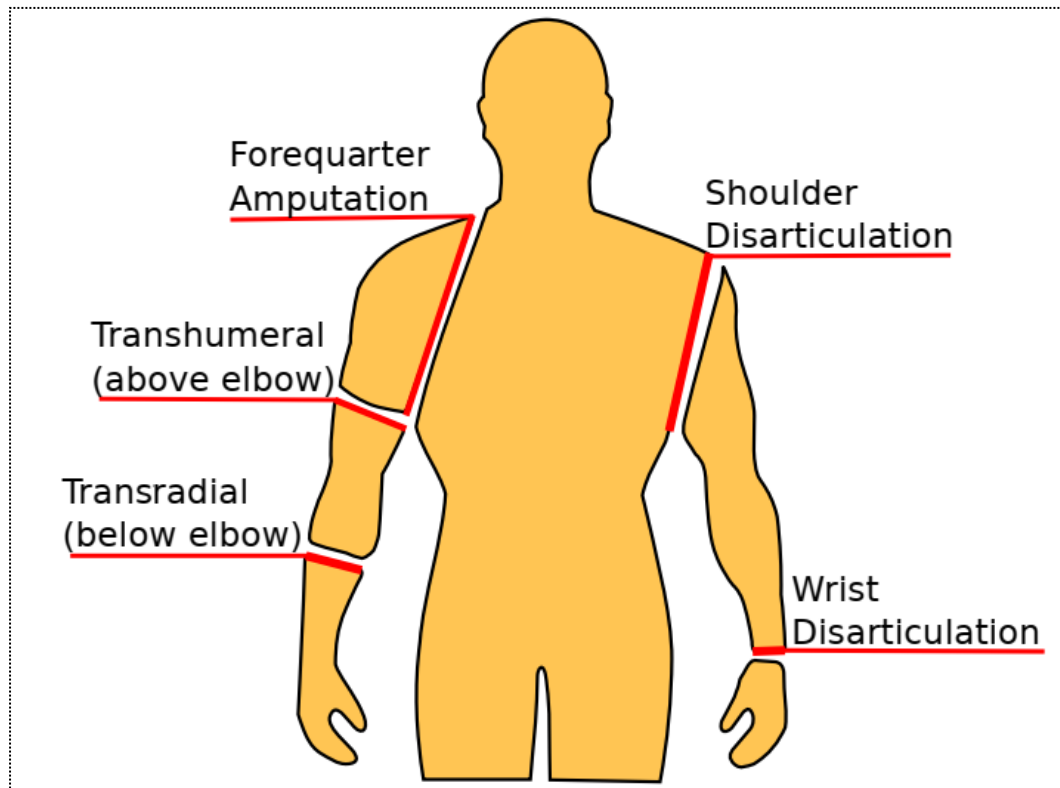


Interossei muscles of left hand (palmar view)

Interossei muscles of left hand (dorsal view)

Terminology

- types of upper-limb deficiency (amputations)



<https://www.cdha.nshealth.ca/amputee-rehabilitation-musculoskeletal-program/patient-family-information/upper-limb-amputations>



<https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-5386178/>

Intent detection and somatosensory feedback

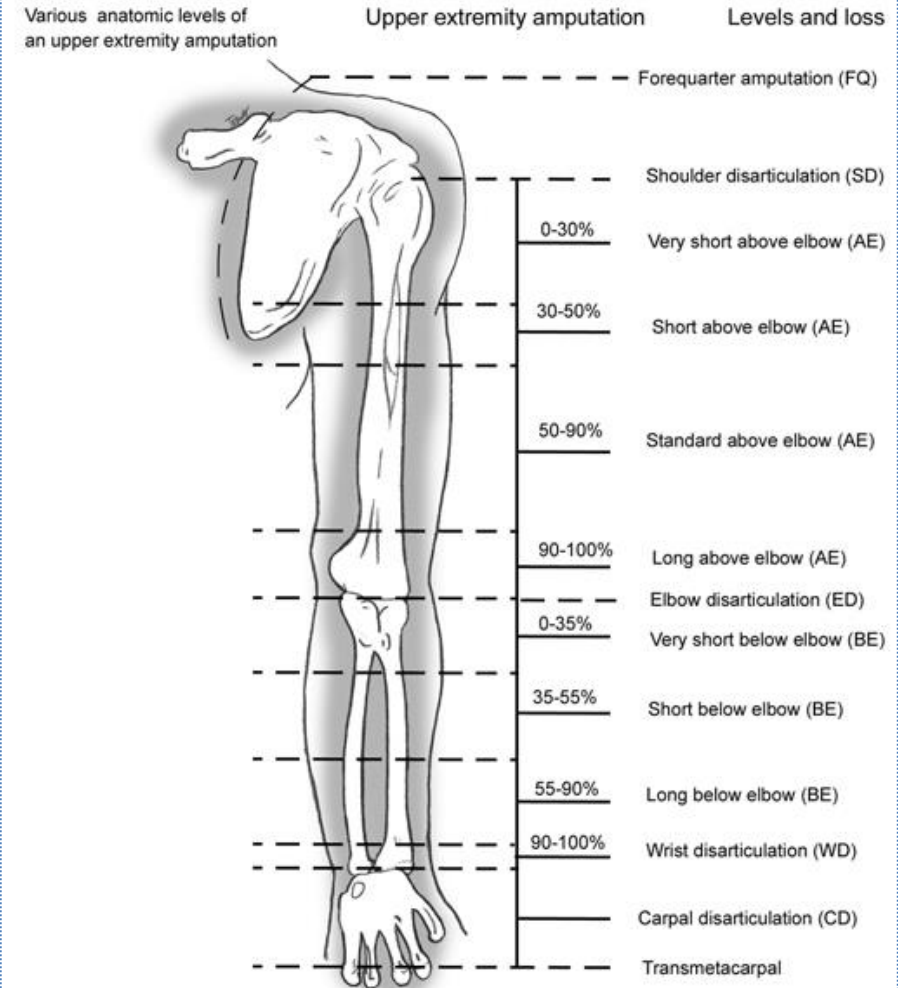
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https://www.physio-pedia.com/Principles_of_Amputation



Take home



<https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-5386178/>

Even tasks which look simple
are often very complex!

Don't spill your coffee!