# Mechanisms and Sensors for Robotic Fingers

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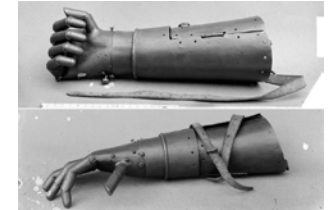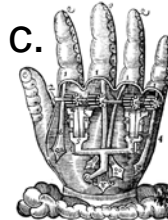
Seminar: Humanoide Roboter, WS 2018/19

Institute for Anthropomatics and Robotics (IAR), High Performance Humanoid Technologies (H2T)
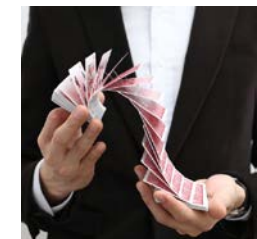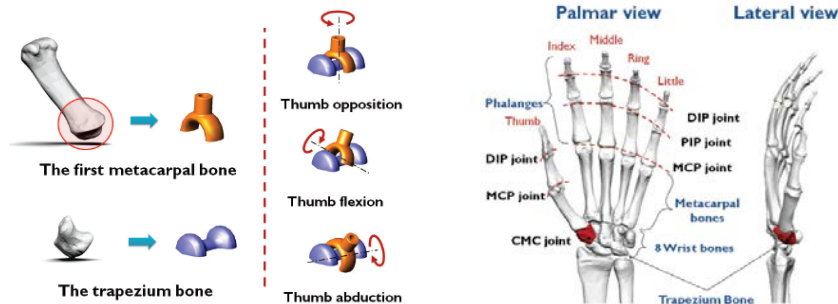
# Introduction

## History

- Metal prosthesis of Goetz von Berlichingen 15$^{th}$ c.
- Ambroise Paré 16$^{th}$ c.
- "La Musicienne" by Jaquet-Droz 18$^{th}$ c.
- Robotic hand with elastic fingers
- ARMAR hand
- Biomimetic robotic hand

## Lessons Learned from Human Hand Studies

- Prehension
- Apprehension
- The thumb
- Dexterity

The first metacarpal bone

The trapezium bone

Thumb opposition

Thumb flexion

Thumb abduction

**Palmar view**     **Lateral view**

Index   Middle   Ring   Little

Phalanges Thumb

DIP joint

DIP joint    PIP joint

MCP joint    MCP joint

CMC joint   Metacarpal bones

8 Wrist bones
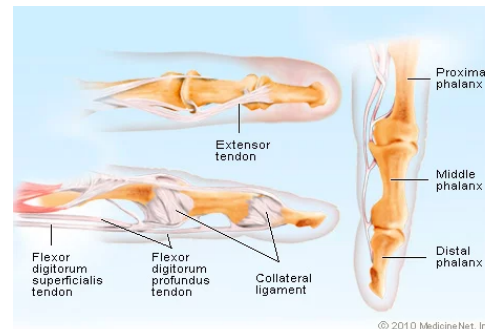
Trapezium Bone

# Introduction

## Applications

- Prosthetic

- tele-manipulation

- Industrial

- Service and care
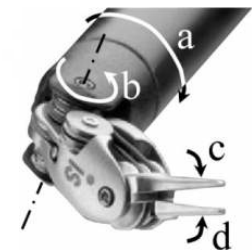
## The Fingers

- A serial bone-link structure

- An actuation muscle system

# Key features of Robotic Fingers

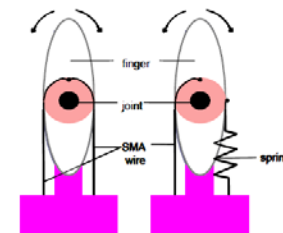- **Level of anthropomorphism**
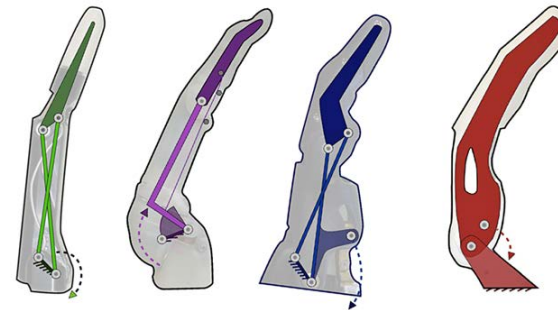  - Size, weight, number of fingers, DoF…

- **Finger Kinematics**

- **Level of actuation**
  - Fully actuated
  - Under actuated

- **Type of actuation**
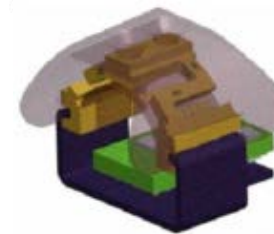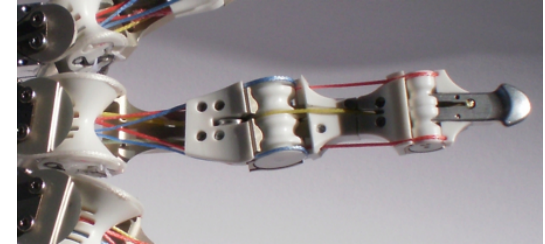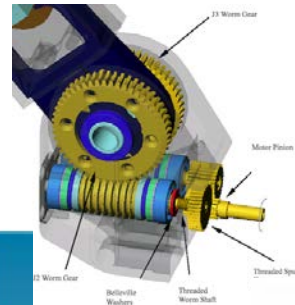  - Electric motors
  - Pneumatic actuators
  - Hydraulic actuators
  - Shape memory alloys (SMA)

# Key features of Robotic Fingers

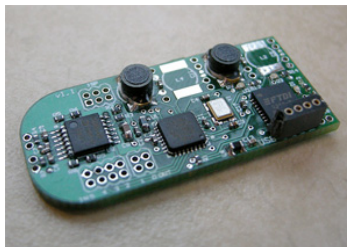- **Type of transmission**
  - tendons and pulleys or sheath
  - rigid connection

- **Level of sensing**
  - Joint / Position sensors
  - Force / Torque sensors
  - Tactile / Touch sensors
  - Other sensors (temperature, olfactory, vision, strain etc.)

# References

1. Ceccarelli, M.: Notes for a history of grasping devices. In: Carbone, G. (Ed.) Grasping in Robotics, pp. 3–17. Springer, Dordrecht (2013)

2. Carbone G. (2013) Stiffness Analysis for Grasping Tasks. In: Carbone G. (eds) Grasping in Robotics. Mechanisms and Machine Science, vol 10. Springer, London

3. Birglen, L., Lalibertè, T., Gosselin, C.: Underactuated Robotic Hands. Springer, Berlin (2008)

4. Mason, M. T. (2005). Mechanics of robotic manipulation. New Delhi: Prentice-Hall of India private.

5. Birglen, L., Gosselin, C., & Lalibertè, T. (2008). Underactuated Robotic Hands. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg.

6. Iberall, T. and MacKenzie, C.: 1990, Opposition space and human prehension, in T. I. S.T. Venkataraman (ed.), Dexterous Robot Hands, Springer-Verlag.

7. Biagiotti, L., Lotti, F., Melchiorri, C., & Vassura, G. (2003). How Far Is the Human Hand ? A Review on Anthropomorphic Robotic End-effectors.

8. Vazhapilli Sureshbabu, A.; Metta, G.; Parmiggiani, A. A Systematic Approach to Evaluating and Benchmarking Robotic Hands - The FFP Index.

9. Yousef, H.; Boukallel, M.; Althoefer, K. Tactile sensing for dexterous in-hand manipulation in robotics A review. Sensors and Actuators A: physical 2011, 167, 171–187.

10. J. E. Huber, N. A. Fleck, and M. F. Ashby. The selection of mechanical actuators based on performance indices. Proceedings of the Royal Society of London A: Mathematical, Physical and Engineering Sciences, 453(1965):2185-2205, 1997.

11. K. Andrianesis and A. Tzes. Design of an anthropomorphic prosthetic hand driven by shape memory alloy actuators. In Biomedical Robotics and Biomechatronics, 2008. BioRob 2008. 2nd IEEE RAS EMBS International Conference on, pages 517-522, Oct 2008.

12. Scarcia, U. (2015). *Design and Control of Robotic Hands* (Doctoral dissertation, alma).

13. Loh, C. S., Yokoi, H., & Arai, T. (2006, January). New shape memory alloy actuator: design and application in the prosthetic hand. In Engineering in Medicine and Biology Society, 2005. IEEE-EMBS 2005. 27th Annual International Conference of the (pp. 6900-6903). IEEE.

14. Ceccarelli, M. (2015). Finger mechanisms for robotic hands. In Recent Advances in Mechanism Design for Robotics (pp. 3-13). Springer, Cham.

15. Townsend W.T. (2017) BarrettHand Grasper: Programmably Flexible Part Handling and Assembly. In: Goswami A., Vadakkepat P. (eds) Humanoid Robotics: A Reference. Springer, Dordrecht

16. Xu, Z., & Todorov, E. (2016, May). Design of a highly biomimetic anthropomorphic robotic hand towards artificial limb regeneration. In Robotics and Automation (ICRA), 2016 IEEE International Conference on (pp. 3485-3492). IEEE.