Presentation of research interests

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Presentation of research interests
at the Department of Electrical Engineering and Computer Science,
University of Stavanger, Norway, 2017

About Me

Education:

- PhD in Engineering Cybernetics, Norwegian University of Science and Technology (NTNU), Norway
- MSc in Computer Science Engineering, University of Siena, Italy
- BSc degree in Computer Science Engineering, University of Catania, Italy

Mobility:

- Visiting Fellow, Technical Aspects of Multimodal Systems (TAMS), Department of Mathematics, Informatics and Natural Sciences, University of Hamburg, Hamburg, Germany
- Visiting Student, School of Computing and Intelligent Systems, University of Ulster, Londonderry, United Kingdom
- Granted with an Erasmus+ Staff Mobility for Teaching and Training project

Activities:

- Membership Development Officer for the IEEE Norway Section

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About Me

Current position:

- Filippo Sanfilippo, Postdoctoral Fellow at the Dept. of Eng. Cybernetics, Norwegian University of Science and Technology (NTNU), Trondheim, Norway

Current courses:

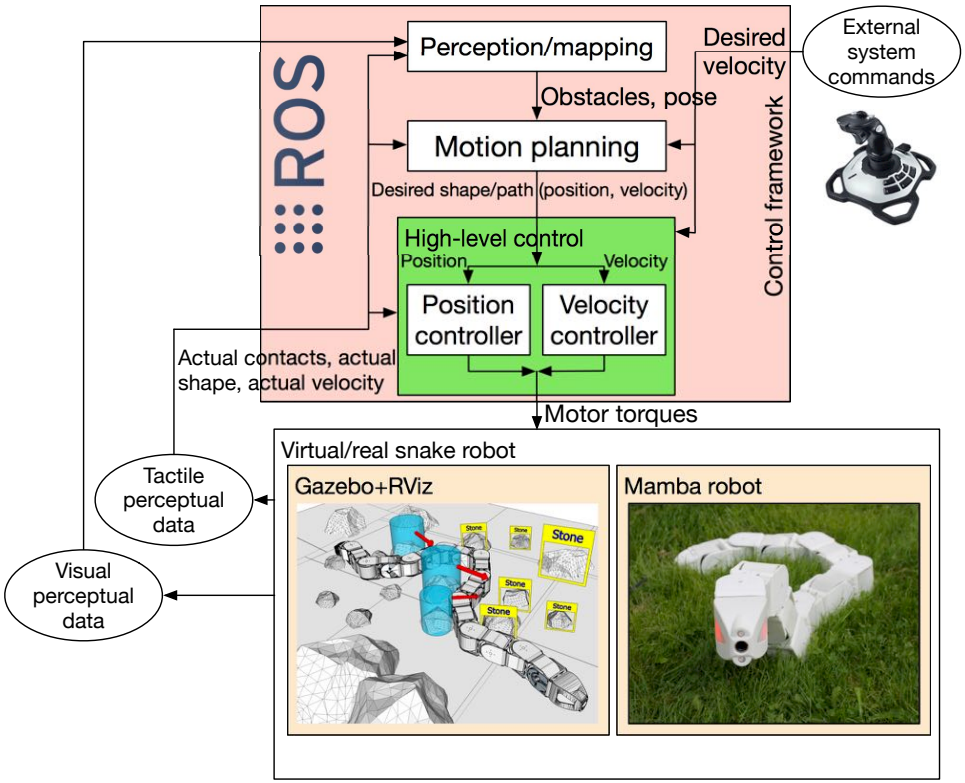
- TTK4235 - Embedded Systems (Lecturer)
- Experts in Teamwork - Snake robots (Supervisor)

Past courses:

- Real-time Computer Programming (Lecturer)
- Mechatronics, Robots and Deck Machines (Teaching Assistant)
- System Simulation in Matlab/Simulink (Lecturer)

Current research topic:

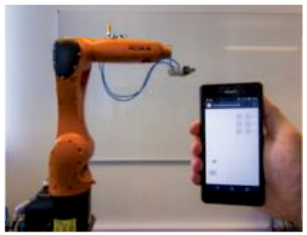
- "SNAKE - Control Strategies for Snake Robot Locomotion in Challenging Outdoor Environments", project number 240072, supported by the Research Council of Norway through the *Young research talents funding scheme*



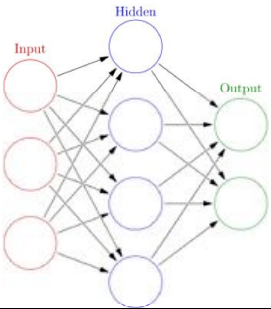
Research topics

Visualisation/Game Development

Mobile Device

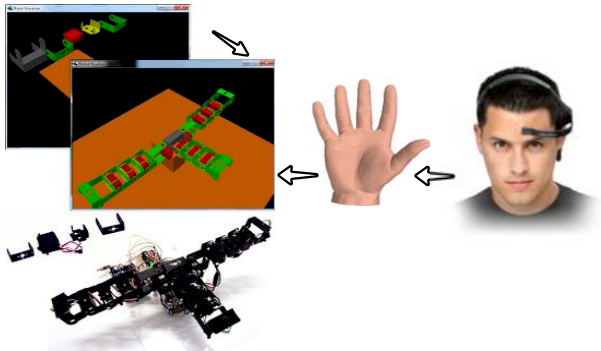


Artificial Intelligence



Augmented Reality/Virtual Reality

Software/Hardware Codesign

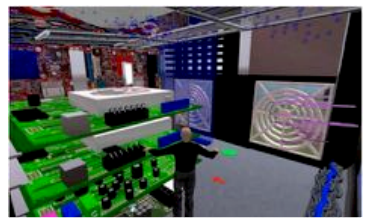


Safety-Critical Systems

Micro-controllers, IoT, Maker Tech.

Real-time Systems

Education



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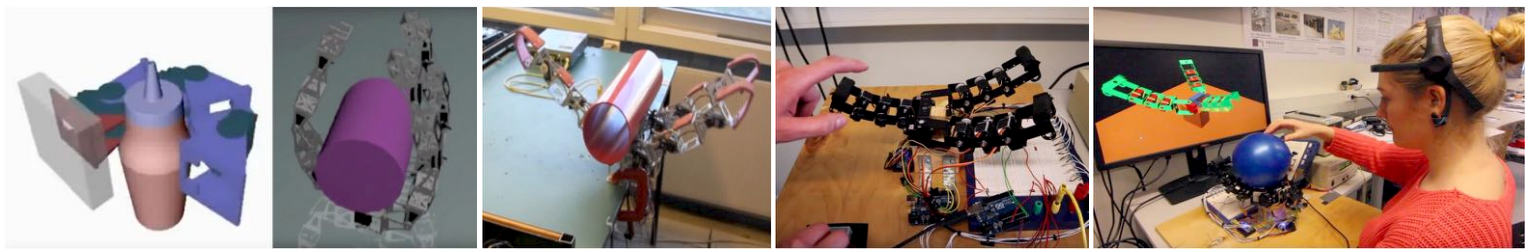
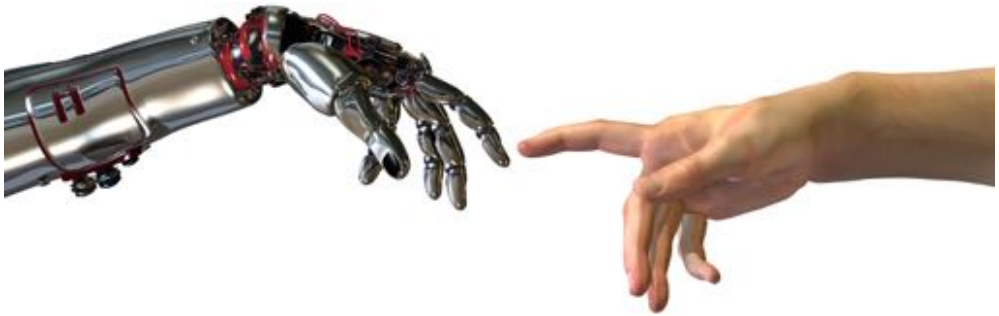
Student projects



Bio-inspired robotic hands



Mimicking the human hand's ability, one of the most challenging problem in bio-inspired robotics:

- large gap in terms of performances.

Classical approach, analysis of the kinematic behavior of the human hand:

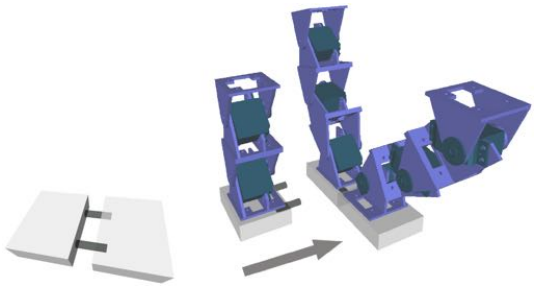
- simplified human hand models with minimum and optimal degrees of freedom[1].

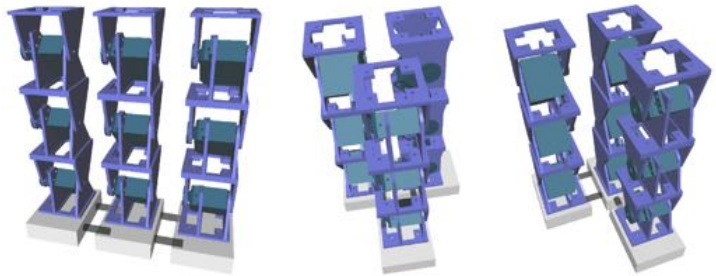
Modular grasping, a promising solution:

- minimum number of degrees of freedom necessary to accomplish the desired task.

[1] S. Cobos, M. Ferre, and R. Aracil. "Simplified human hand models based on grasping analysis". In: *Proc. of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2010, pp. 610–615.

Modular grasping

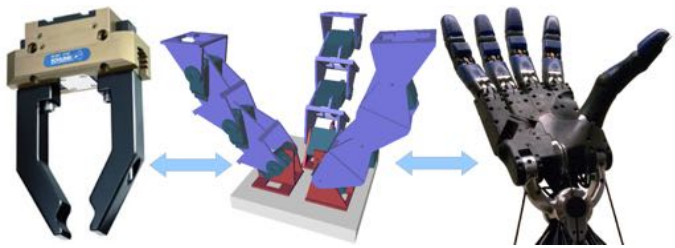




- A trade off between a simple gripper and more complex human like manipulators.
- *Principle of minimalism*: choose the simplest mechanical structure, the minimum number of actuators, the simplest set of sensors, etc.

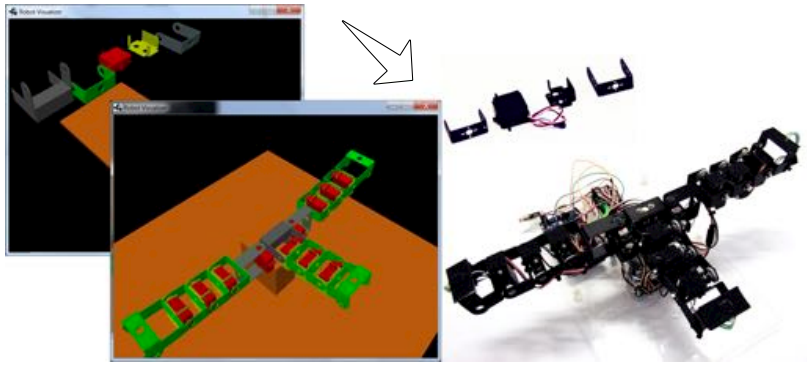
Modular grasping:

- identical modules are used to build linkages in order to realise the grasping functions. From a mechanical point of view, even if it is not the most efficient grasping approach, the modular grasping still meets the requirements of standardisation, modularisation, extendibility and low cost[2].



[2] Filippo Sanfilippo et al. "Efficient modular grasping: an iterative approach". In: *Proc. of the 4th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob), Rome, Italy*. 2012,

ModGrasp: a rapid-prototyping framework for designing modular hands



ModGrasp:

- Modular Mechanics;
- Modular Hardware;
- Modular Software.

ModGrasp, a rapid-prototyping framework for low-cost sensorised modular hands:

- real-time one-to-one correspondence between virtual and physical prototypes;
- on-board, low-cost torque sensors, 3-D visualisation environment;

ModGrasp, not only an engineering tool but mostly a scientific tool:

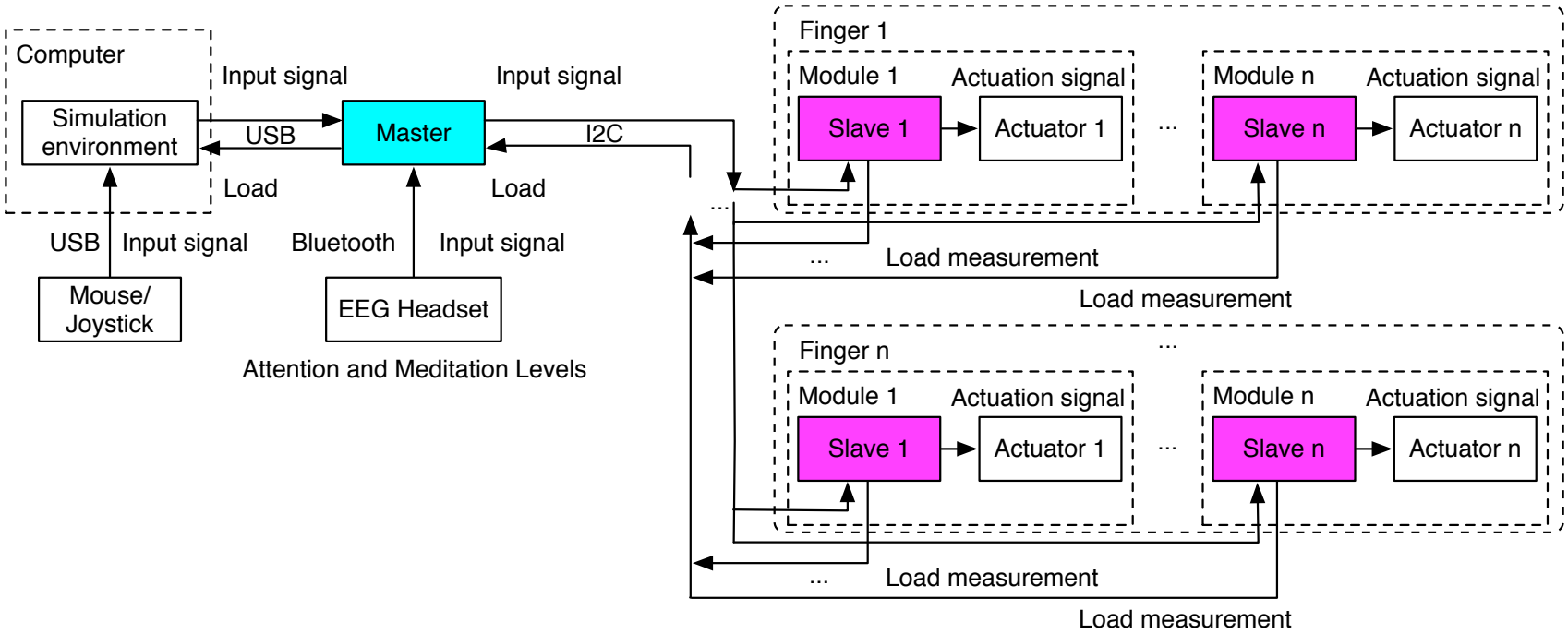
- a framework that can be used to discover new ways of controlling modular hands.

[3,4]

[3] Filippo Sanfilippo et al. "ModGrasp: An open-source rapid-prototyping framework for designing low-cost sensorised modular hands". In: *Proc. of the 5th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob), São Paulo, Brazil*. 2014, pp. 951–957.

[4] Filippo Sanfilippo, Houxiang Zhang, and Kristin Ytterstad Pettersen. "The New Architecture of ModGrasp for Mind-Controlled Low-Cost Sensorised Modular Hands". In: *Proc. of the IEEE International Conference on Industrial Technology (ICIT2015), Seville, Spain*. 2015, pp. 524–529.

ModGrasp architecture



- Master-slave communication. Each module is controlled by a slave controller board, which communicates with a master controller board. The controlled manipulators are simulated in a 3-D visualisation environment that communicates with the master controller.
- Extremely robust to hardware failures. If one or more modules break or are disassembled from a prototype, the manipulator keeps working with the remaining functioning joints.

Controller boards

Controller boards, open hardware with Arduino:

- an *Arduino Uno* board based on the *ATmega328* micro-controller is used as the master, while one *Arduino Nano* board is used as a slave to control each finger joint;
- easy maintenance, reliability and extensibility.

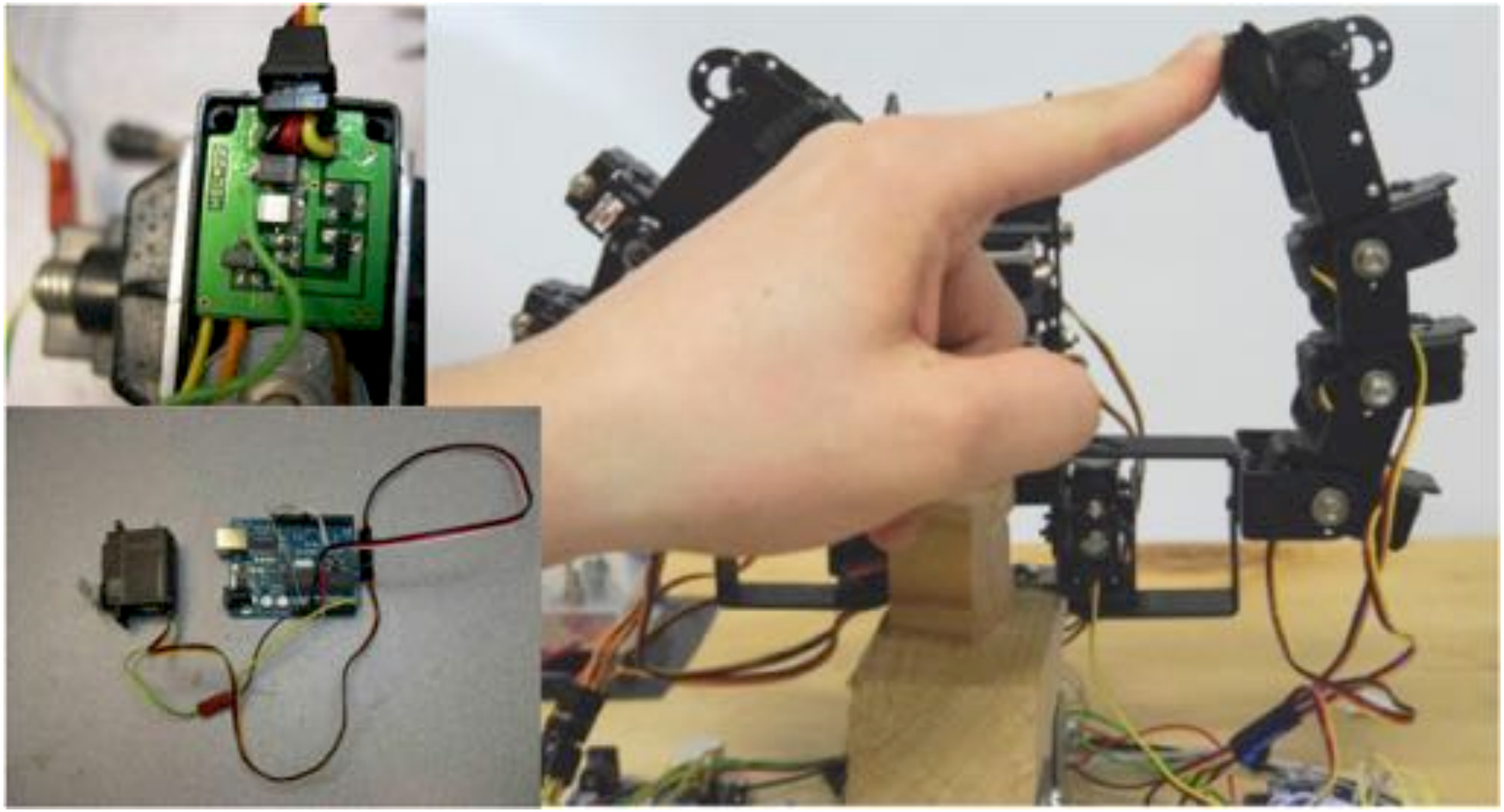
Support for different input devices:

- directly controlled from the simulator environment by means of a computer mouse/joystick or work stand-alone and be controlled by means of a set of potentiometer shafts that are used as input controllers.

Communication protocol:

- the standard I^2C is used as a communication protocol. The physical manipulator models communicate with the simulation environment through the serial interface.

Low-cost torque sensing and joint compliance

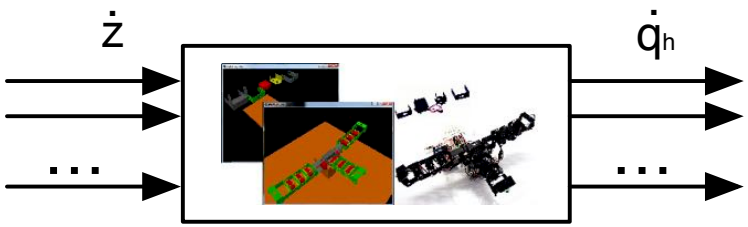


Control approach

[5]

[5] M. Santello, M. Flanders, and J. F. Soechting. "Postural hand synergies for tool use". In: *The Journal of Neuroscience* 18.23 (1998), pp. 10105–10115.

A three-fingered modular manipulator



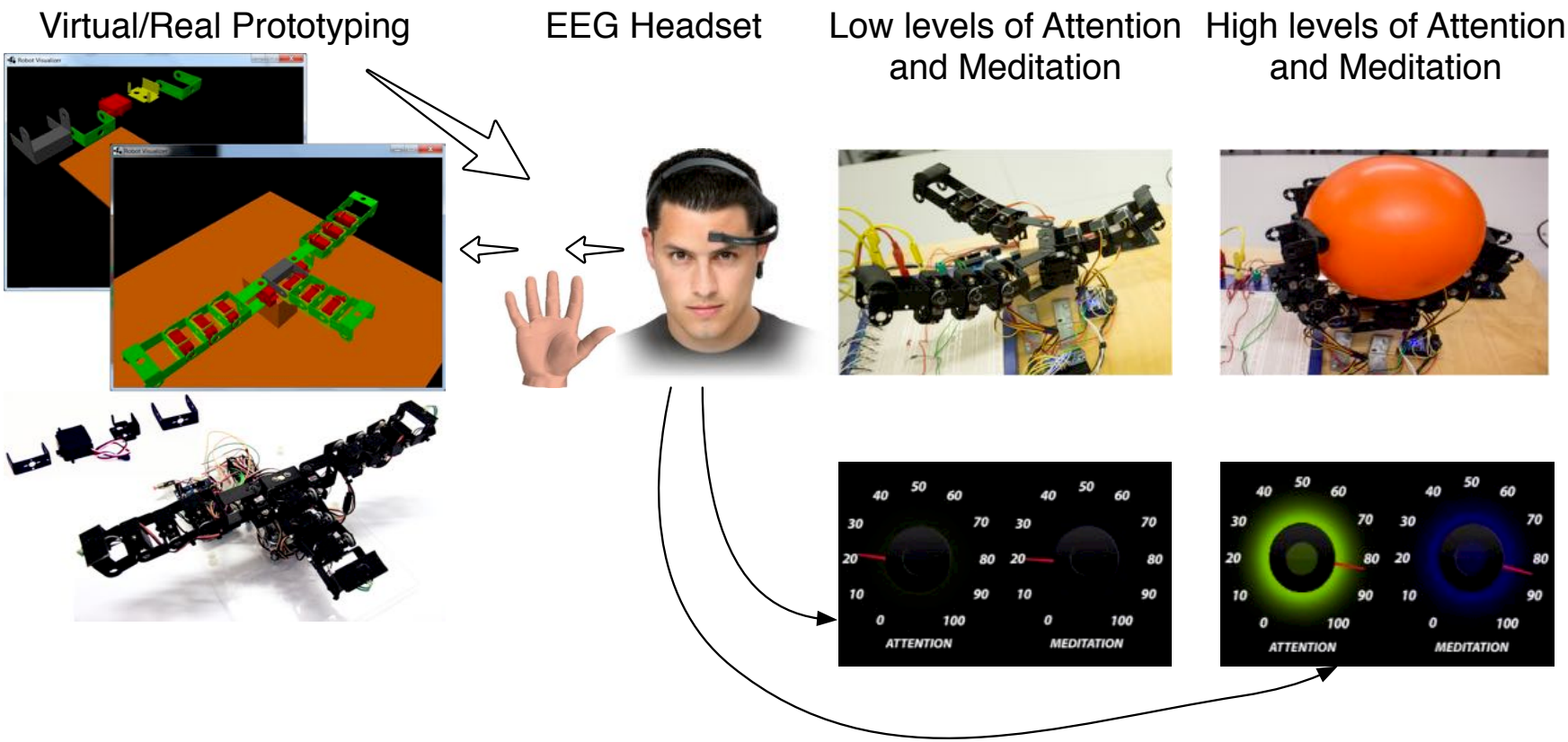
Let $\mathbf{q}_h \in \Re^{n_{q_h}}$, with n_{q_h} representing the number of actuated joints. The subspace of all configurations can be represented by an input vector $\mathbf{z} \in \Re^{n_z}$ (with n_z denoting the number of inputs and $n_z \leq n_{q_h}$) which parameterises the motion of the joint variables along the *synergies*:

$$\dot{\mathbf{q}}_h = \mathbf{S}_h \dot{\mathbf{z}}, \tag{1}$$

being $\mathbf{S}_h \in \Re^{n_{q_h} \times n_z}$ the synergy matrix.

$$\mathbf{S}_h = \begin{bmatrix} -0.7 & 0 \\ -0.2 & 0 \\ -0.1 & 0 \\ 0 & -1.6 \\ -0.7 & 0 \\ -0.2 & 0 \\ -0.1 & 0 \\ 0 & 1.6 \\ -0.7 & 0 \\ -0.2 & 0 \\ -0.1 & 0 \end{bmatrix} \begin{matrix} \} \textit{Thumb} \\ \\ \\ \} \textit{Finger1.} \\ \\ \\ \\ \} \textit{Finger2} \\ \\ \\ \end{matrix} \tag{2}$$

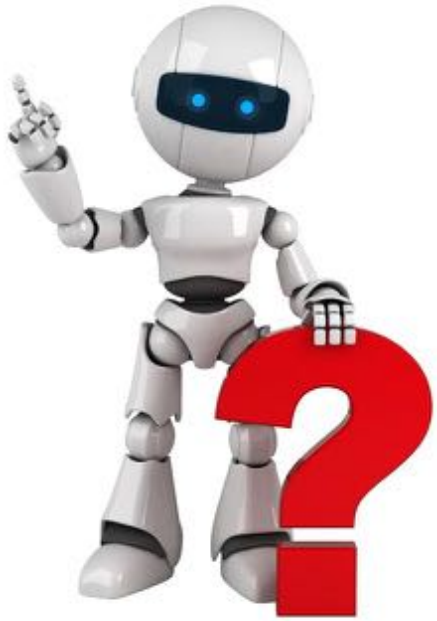
Control objective idea



Experimental results

Conclusion and future work

Thank you for your attention



ModGrasp repository and support:

- *ModGrasp* is an open-source project and it is available on-line at `https://github.com/aauc-mechlab/modgrasp`, along with several class diagrams, all the mechanics, hardware schematics and demo videos;
- F. Sanfilippo, Department of Engineering Cybernetics, Norwegian University of Science and Technology, 7491 Trondheim, Norway, filippo.sanfilippo@ntnu.no.

References

[1] S. Cobos, M. Ferre, and R. Aracil. "Simplified human hand models based on grasping analysis". In: *Proc. of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2010, pp. 610–615.

[2] Filippo Sanfilippo et al. "Efficient modular grasping: an iterative approach". In: *Proc. of the 4th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob), Rome, Italy*. 2012, pp. 1281–1286.

[3] Filippo Sanfilippo et al. "ModGrasp: An open-source rapid-prototyping framework for designing low-cost sensorised modular hands". In: *Proc. of the 5th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob), São Paulo, Brazil*. 2014, pp. 951–957.

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