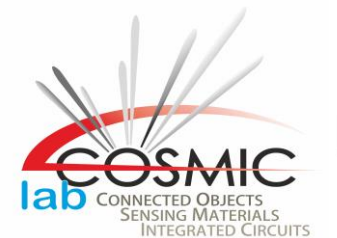
Innovative ICT system to restore the sense of touch in patients with sensory deficit

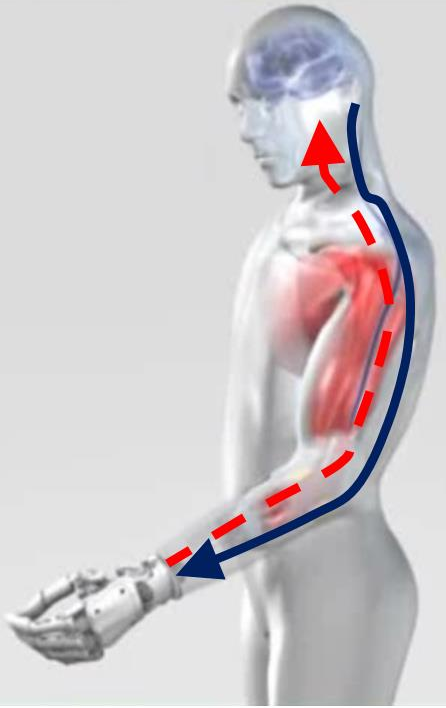
Prof. Maurizio Valle
Università di Genova

3rd WORKSHOP
"Electronics for Sensors" and "Biomedical Applications Technologies & Sensors"

Università Magna Græcia di Catanzaro
6 october 2020



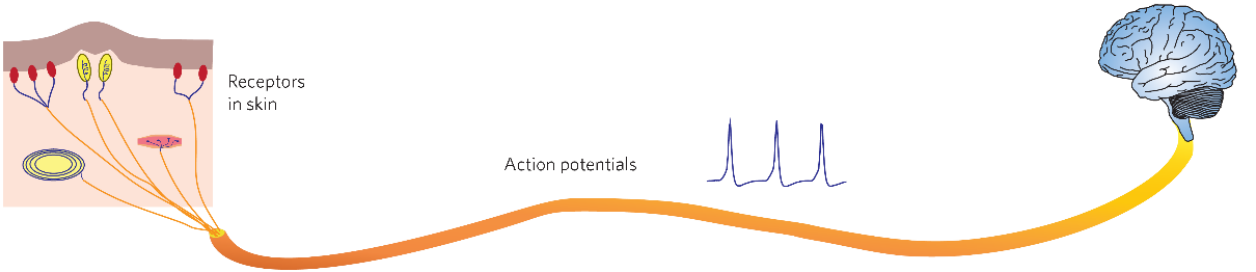
MOTIVATION



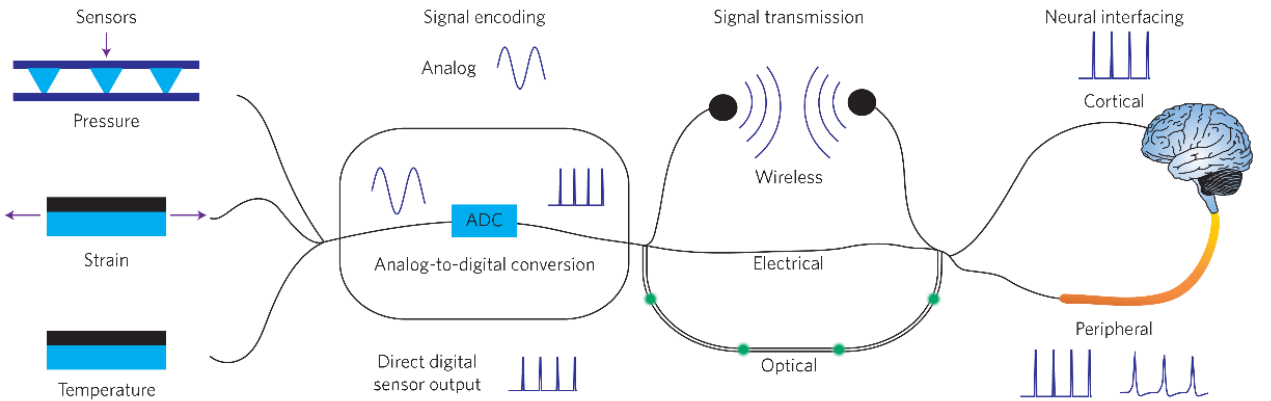
EXISTING: Intuitive motor control from the brain to the prosthesis

MISSING: Sensory feedback from the prosthesis to the brain

Courtesy of Otto Bock ®



Artificial skin transduction



Chortos, A., Liu, J. and Bao, Z., 2016. Pursuing prosthetic electronic skin. Nature materials, 15(9), pp.937-950. DOI: 10.1038/nmat4671

System

- Distributed pressure sensors
- Embedded electronics
- Feedback

Applications

- Upper limb amputees
- Post stroke patients

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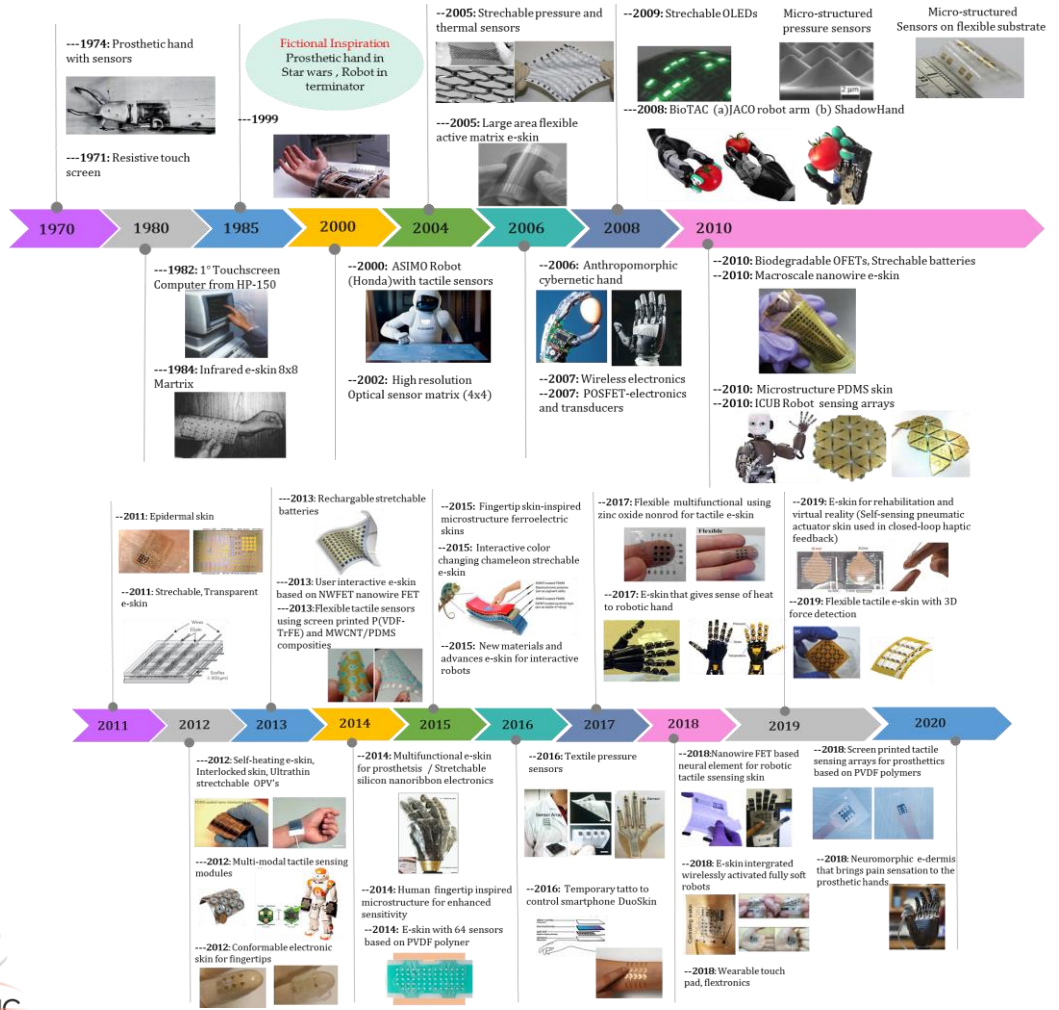
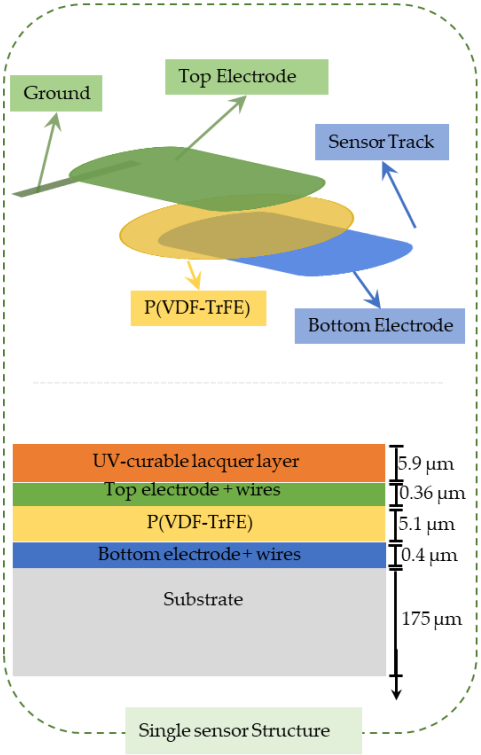
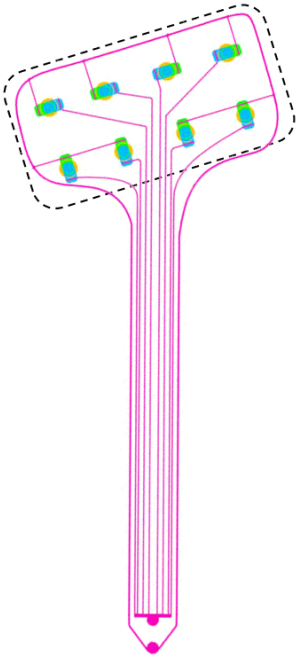
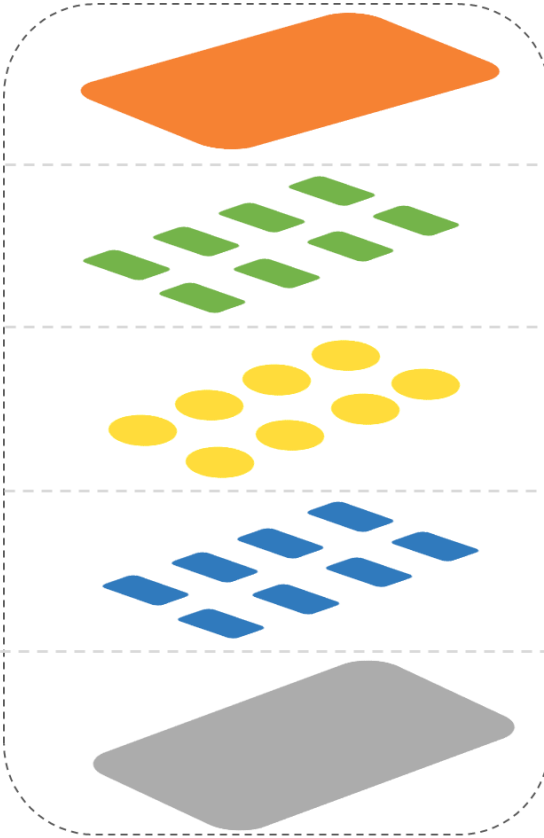


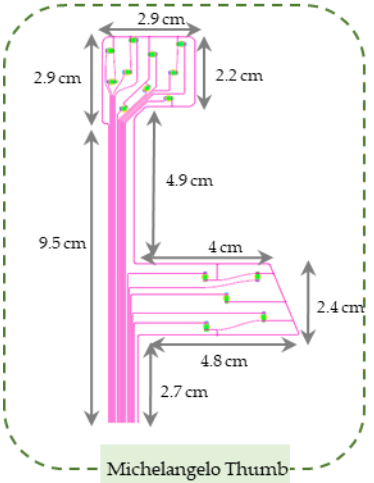
Images credits: Hoda Fares, Post doc researcher, COSMIC Lab., University of Genova



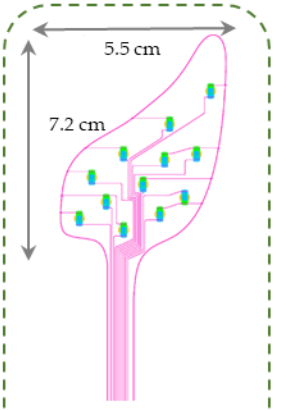




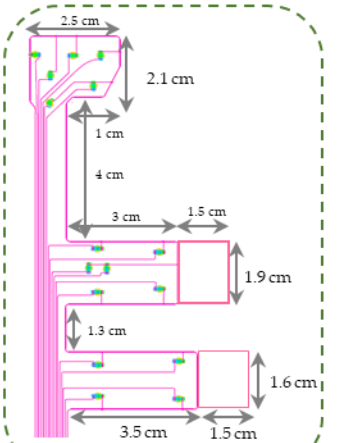
Images credits: Yahya Abbas, Ph.D. student, COSMIC Lab., University of Genova



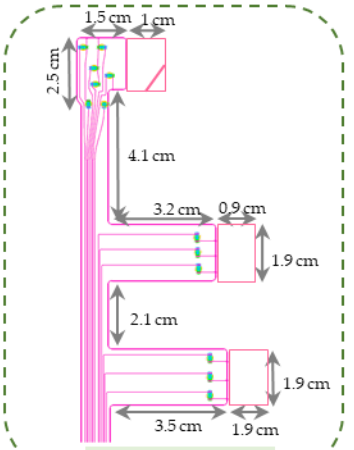
Michelangelo Thumb



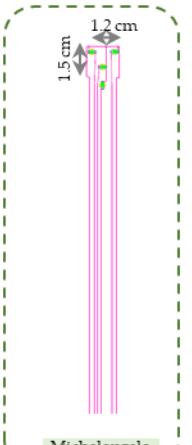
Michelangelo Palm



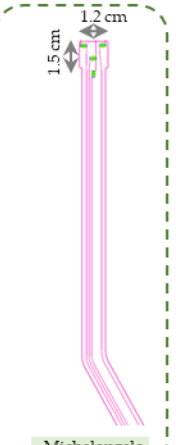
Michelangelo Index



Michelangelo Middle



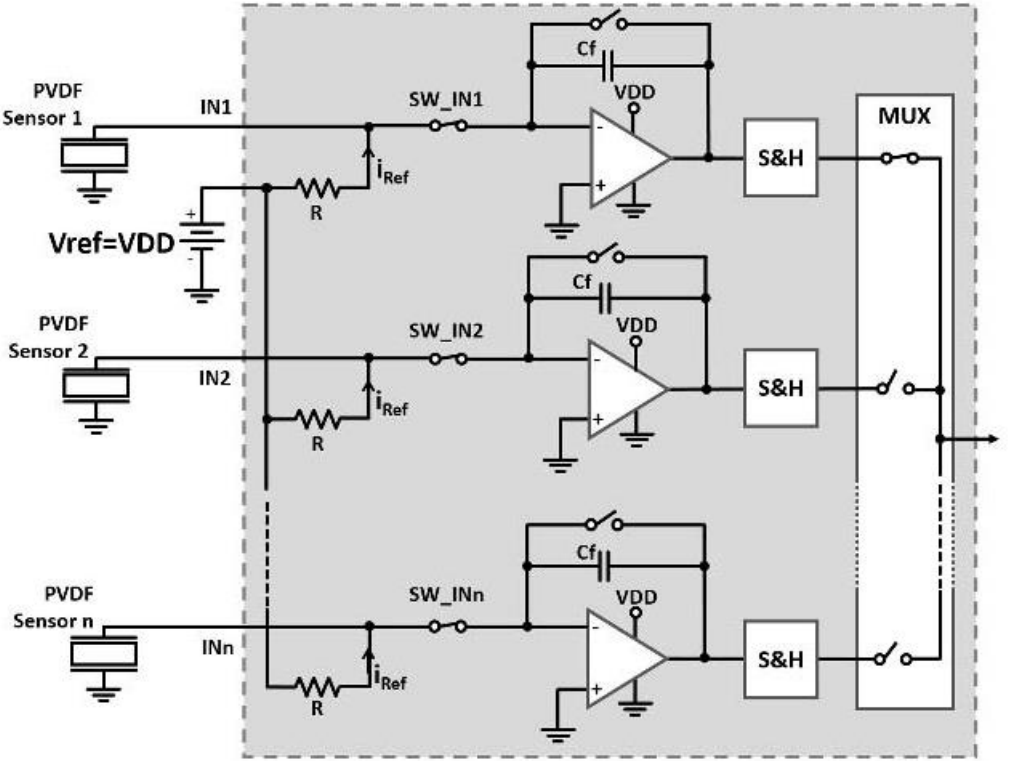
Michelangelo Ring



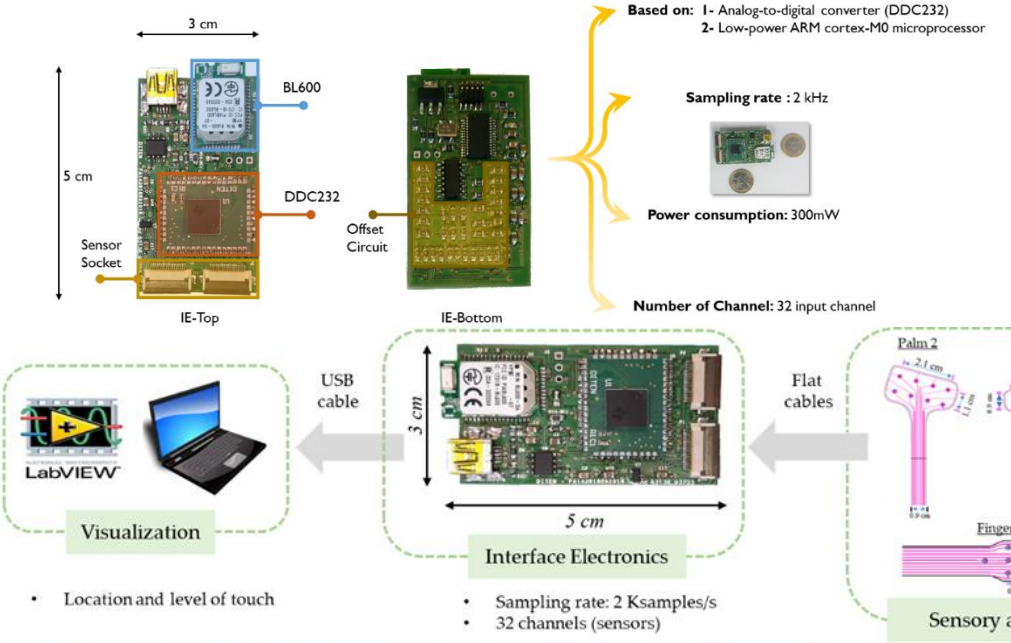
Michelangelo Little

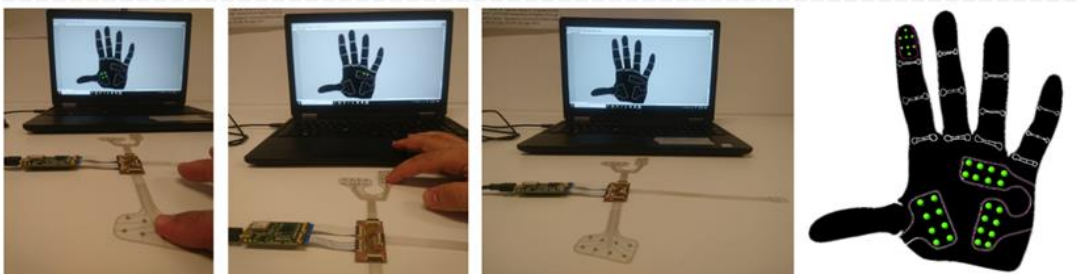
System

- Distributed pressure sensors
- Embedded electronics
- Feedback



Basic electrical circuit diagram of the proposed interface electronics.



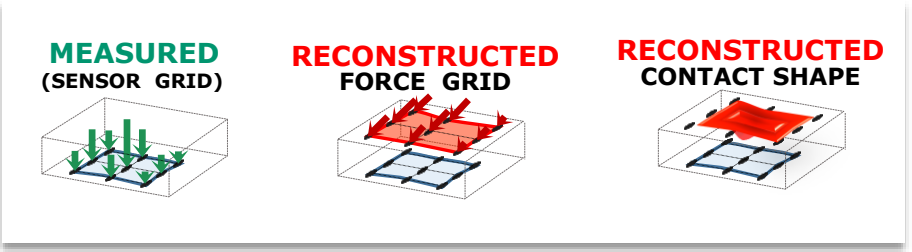


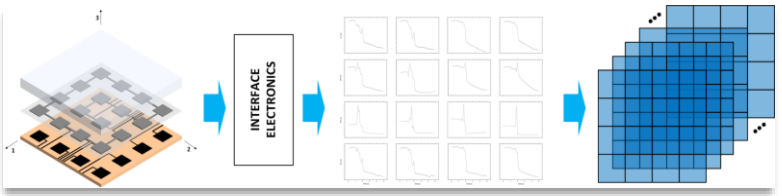
Images credit: Yahya Abbas, Ph.D. student, COSMIC Lab., University of Genova

Embedded and real time management of tactile data

Force - shape reconstruction

Solids mechanics approach





Contact detection + location feature extraction

Tensor-based ML approach

(local features extraction decreases amount of data to be transmitted to high levels)

Images credit: Lucia Seminara, COSMIC Lab., University of Genova

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- **cortical neural interfaces** that record and stimulate neurons directly in the **brain**

- interface with the **peripheral nervous system**:
  - through the intact skin of the amputee's residual arm e.g. **electrocutaneous stimulation**

    or
  - through the sensory nerves with electrical stimulation e.g. **implanted electrodes**

Example of electrocutaneous stimulation patterns

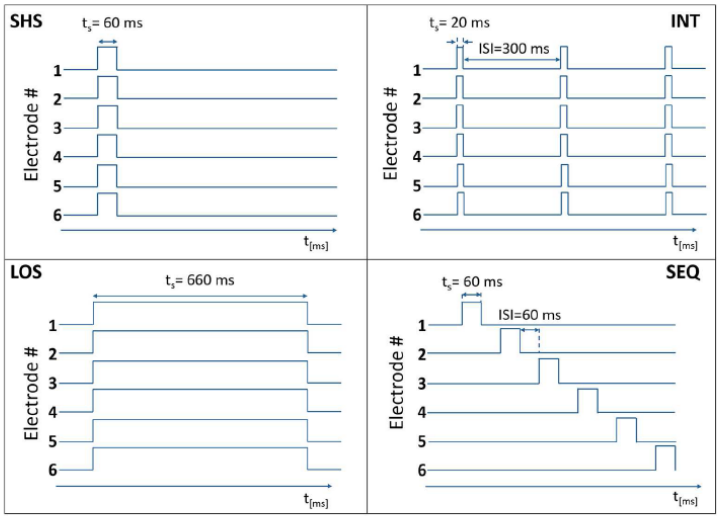
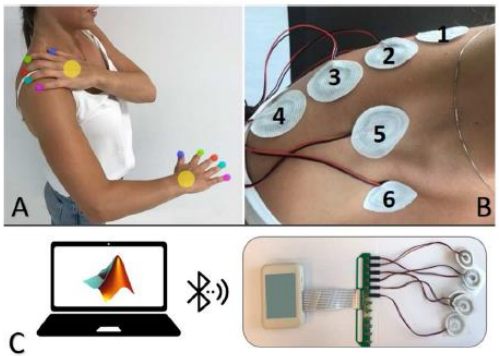
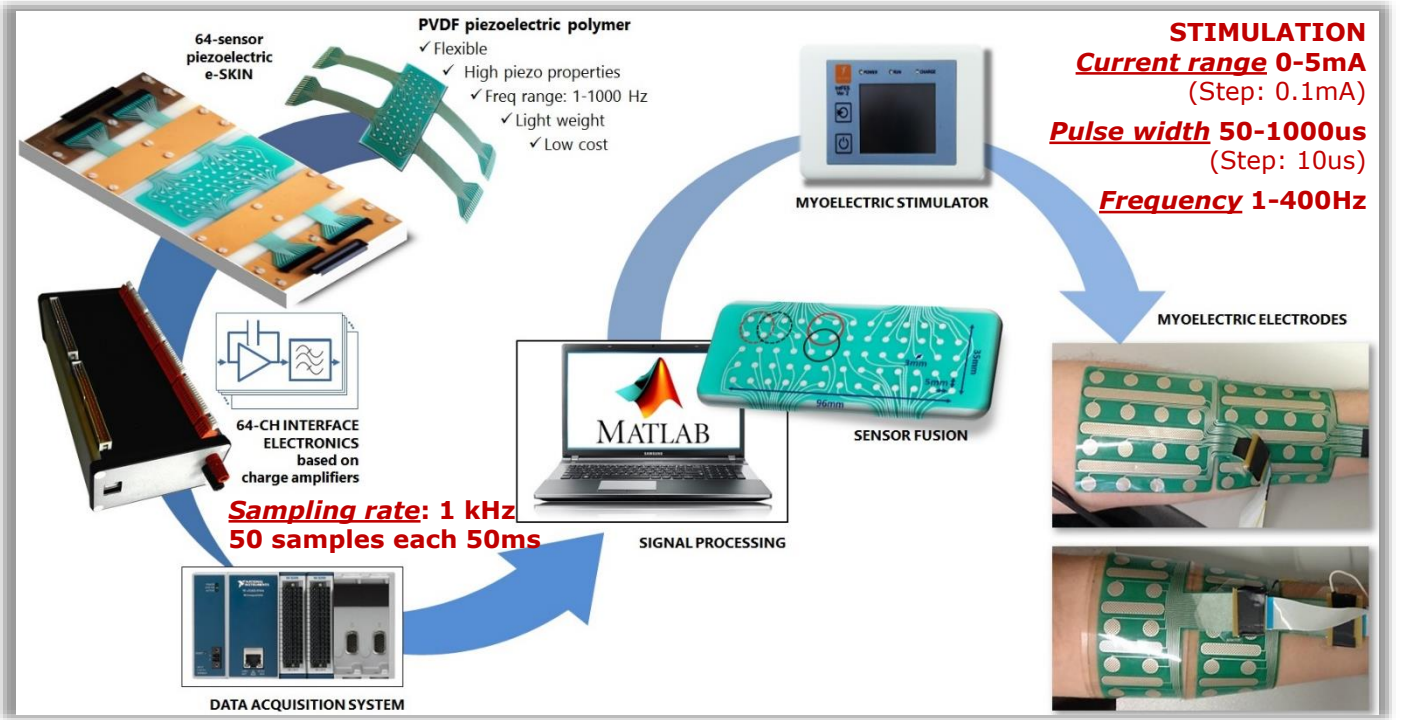


FIGURE 2 | Temporal activation of electrodes in the four electrotactile codes with the time on the x-axis (t_s = stimulation time) and the electrode state (0 – non-active, 1 – active) on the y-axis. In this example, six electrodes were activated.



Nataletti, S., Leo, F., Seminara, L., Trompetto, C., Valle, M., Dosen, S., Brayda, L. Temporal Asynchrony but Not Total Energy Nor Duration Improves the Judgment of Numerosity in Electrotactile Stimulation (2020) Frontiers in Bioengineering and Biotechnology, 8, art. no. 555, DOI: 10.3389/fbioe.2020.00555 PUBLISHER: Frontiers Media S.A.



Franceschi, M., Seminara, L., Dosen, S., Strbac, M., Valle, M., Farina, D., "A System for Electrotactile Feedback Using Electronic Skin and Flexible Matrix Electrodes: Experimental Evaluation", (2017) IEEE Transactions on Haptics, 10 (2), art. no. 7592935, pp. 162-172. DOI: 10.1109/TOH.2016.2618377

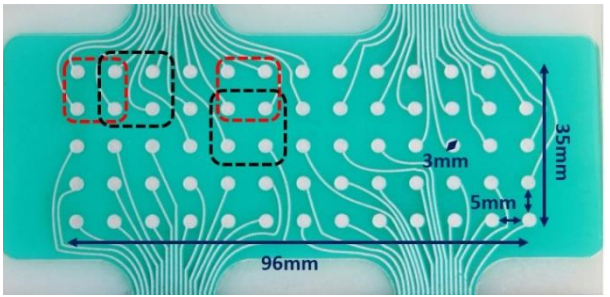
E-SKIN based on PVDF sensors

Signal Conditioning & Data Acquisition

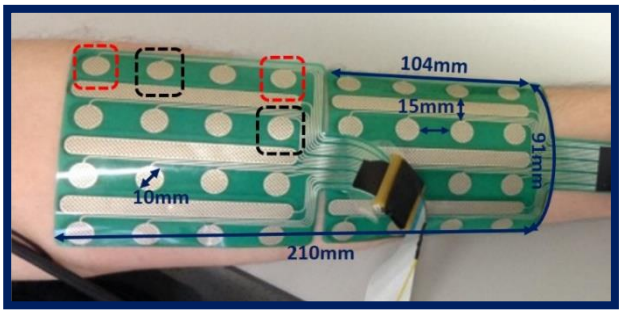
Data Processing: Integrative Method and Sensor Fusion

Multichannel Electrotactile Stimulator

Flexible Matrix Electrodes

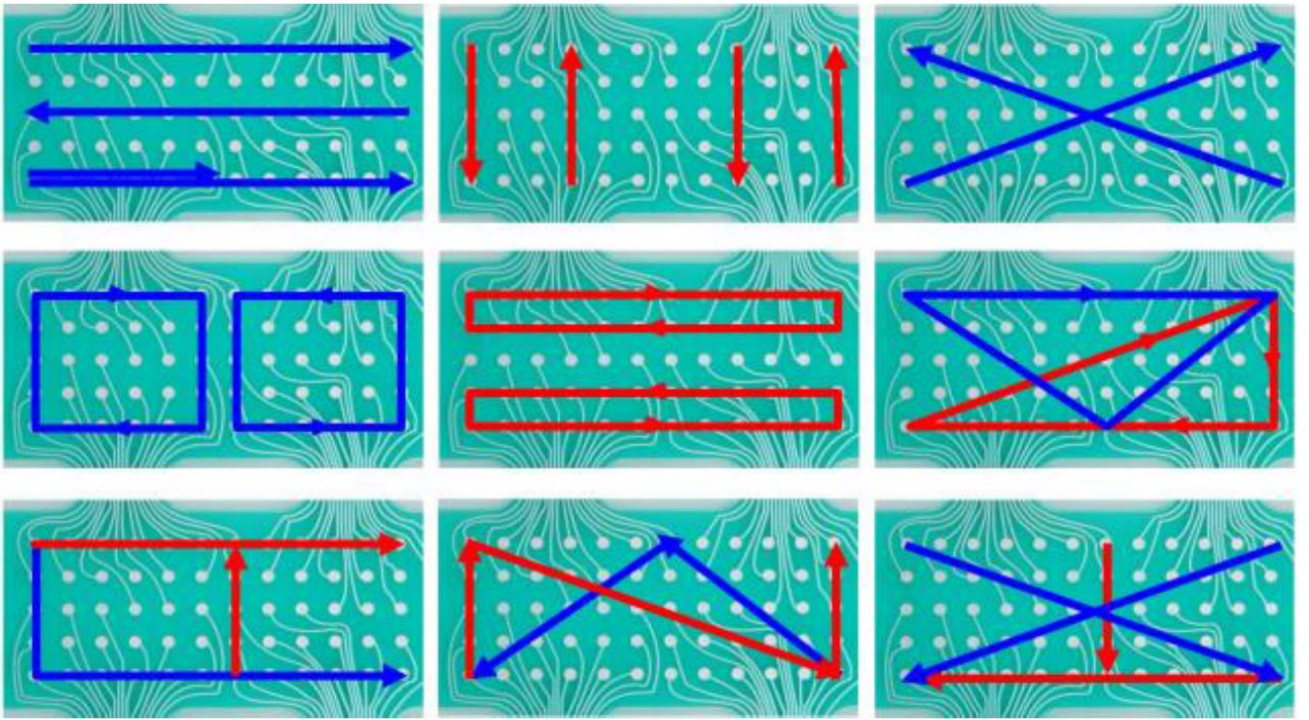


SENSING



STIMULATION

Franceschi, M., Seminara, L., Dosen, S., Strbac, M., Valle, M., Farina, D., “A System for Electrotactile Feedback Using Electronic Skin and Flexible Matrix Electrodes: Experimental Evaluation”, (2017) IEEE Transactions on Haptics, 10 (2), art. no. 7592935, pp. 162-172. DOI: 10.1109/TOH.2016.2618377



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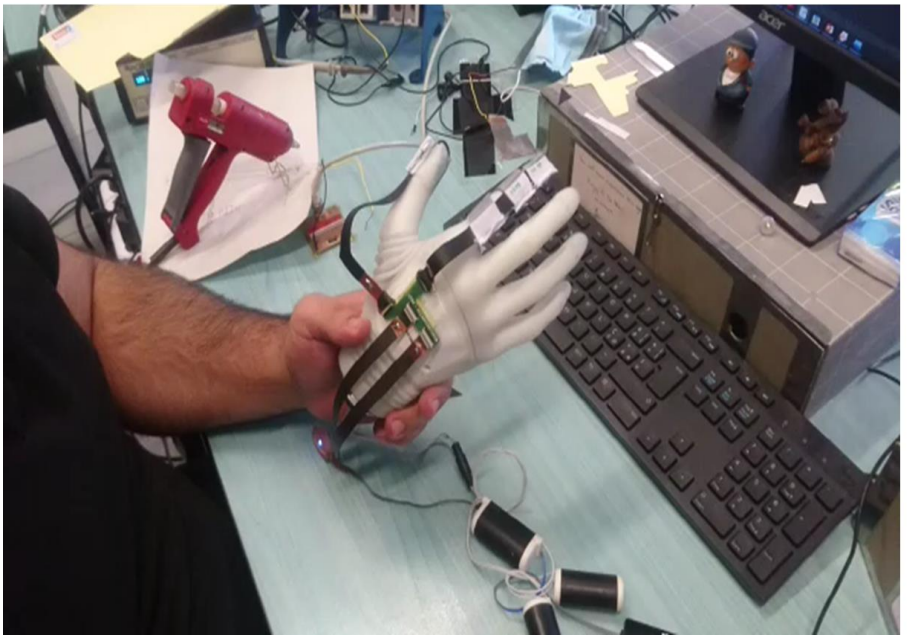
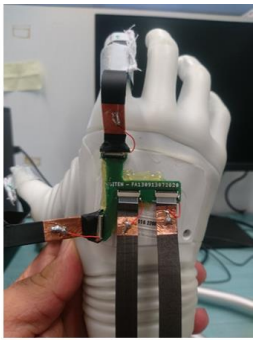
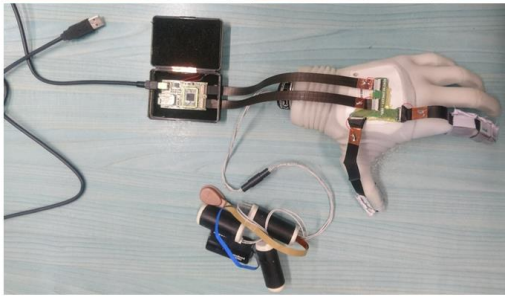
- Upper limb amputees
- Post stroke patients

H2020 Tactility project: Tactile feedback enriched interaction through virtual reality and beyond (2019 -2022)







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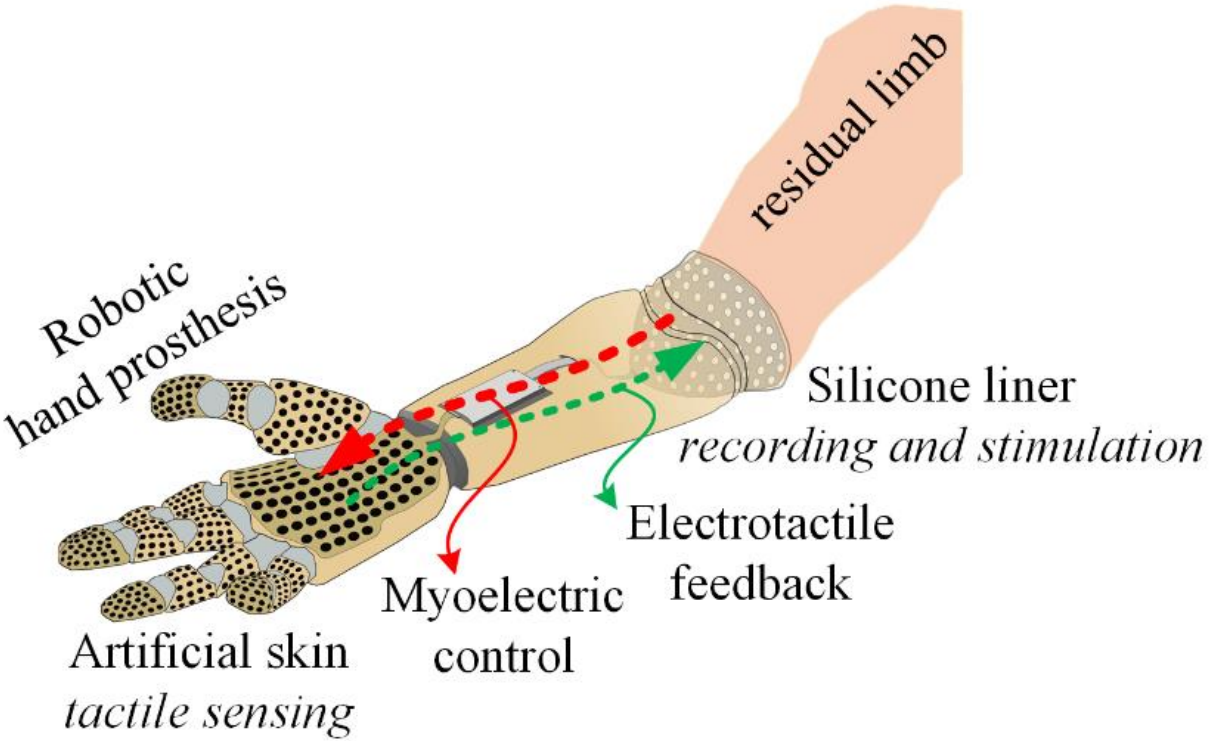

Lucia Seminara, Matija Strbac, Youssef Amin, Maurizio Valle, Strahinja Dosen, “Artificial Skin and Electrotactile Stimulation for Advanced Tactile Feedback in Myoelectric Prostheses”, in Electronic skin: sensors and systems, Ali Ibrahim aand Maurizio Valle (Editors), River Publisher, 2020

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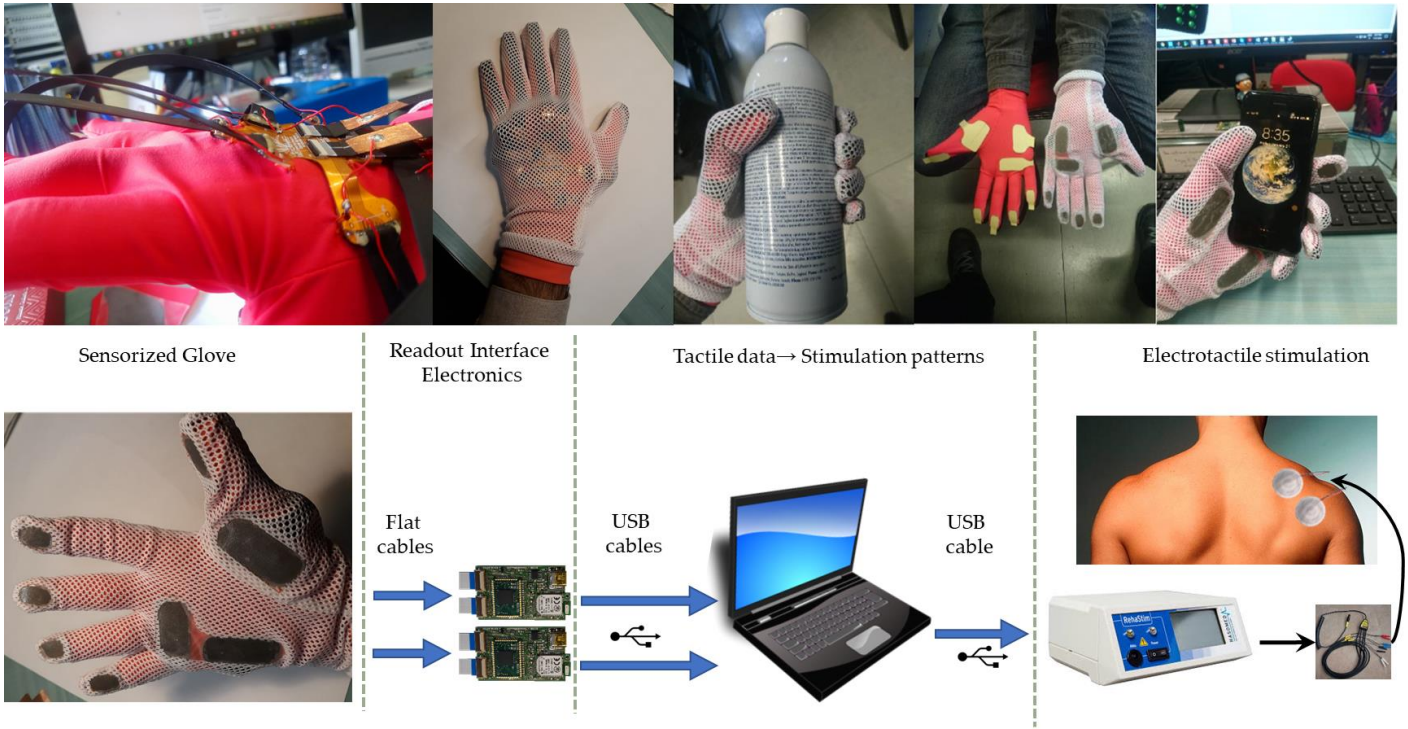
Progetto finanziato dalla Compagnia di San Paolo, grant number: 2017.0559



Images credits: Yahya Abbas, Ph.D. student, COSMIC Lab., University of Genova

Acknowledgments COSMIC Lab people

Faculty

Lucia Seminara

Ph.D. students

Yahya Abbass

Moustafa Saleh

Youssef Amin

Post doc researchers

Hoda Fares

Ex alumni

Luigi Pinna

Ali Ibrahim

Marta Franceschi

……..

GRAZIE