DEASCUOLA

Dai banchi di scuola alle professioni green del futuro

14 Febbraio 2023

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CREATRICE DI ROBOT BIOISPIRATI

Laura Margheri
Post Doc, Bioinspired Soft Robotics Lab
Istituto Italiano di Tecnologia

iit ISTITUTO ITALIANO DI TECNOLOGIA

14 Febbraio 2023

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Indice

DEASCUOLA | a2a LIFE COMPANY

La Robotica Bioispirata

Scienza e tecnologia

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La Robotica oggi – cosa è un robot?

Machine capable of carrying out a complex series of actions automatically
(Oxford English Dictionary)

Autonomous machine, capable of sensing its environment, carrying out computations to make decisions, and performing actions in real world
IEEE (Rodney Brooks, founder and former CTO of iRobot, Rethink Robotics, and currently of Robust.AI)

Machine that senses, thinks, acts (perceives, decides what to do in response, then acts on the world)
Gill Pratt, CEO at Toyota Research Institute

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Cos’è la Robotica Bioispirata?

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Il talento della Natura nella complessità del mondo

<u>Adattabilità</u>: la chiave per la sopravvivenza

Immagini tratte da: pixabay.com

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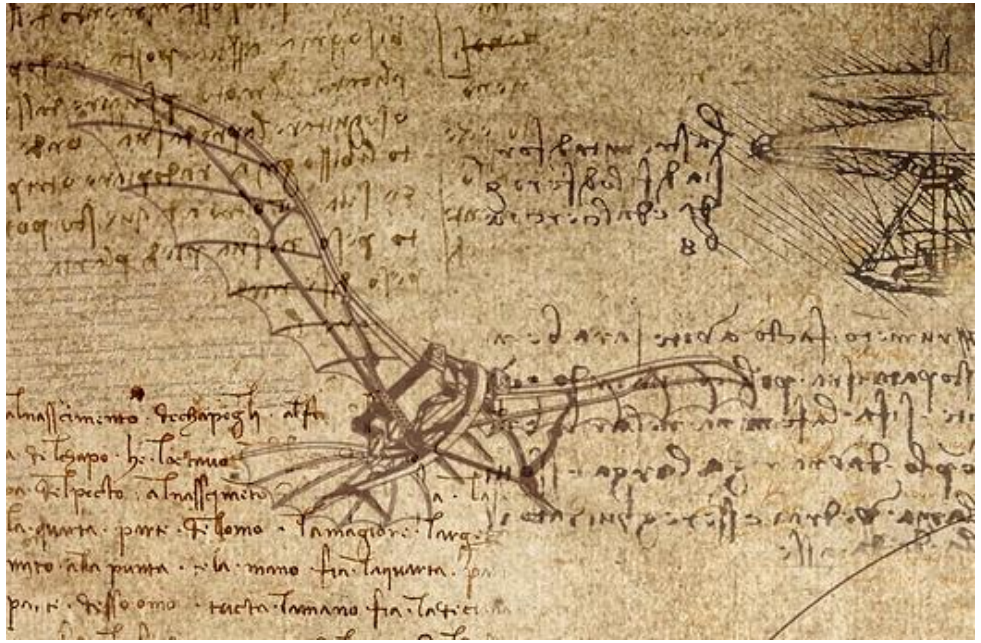
Bioispirazione... da oltre 500 anni



"Come per tutt'i viaggi si pò imparare.
Questa benigna natura ne provvede in modo
che per tutto il mondo tu trovi dove imitare."

Leonardo da Vinci

Immagini tratte da: pixabay.com

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Bioispirazione... da oltre 500 anni

Dall'effetto delle foglie di loto

Nelumbo nucifera, o "fior di loto"

Dagli uncini dei fiori di bardana

Arctium lappa, o "bardana maggiore"

Dall'architettura arborea

alle superfici idrofobiche e autopulenti

al Velcro
(*velours: velluto + crochet: uncino*)

alla volta e giochi di luce della Sagrada Familia

Immagini tratte da: pixabay.com

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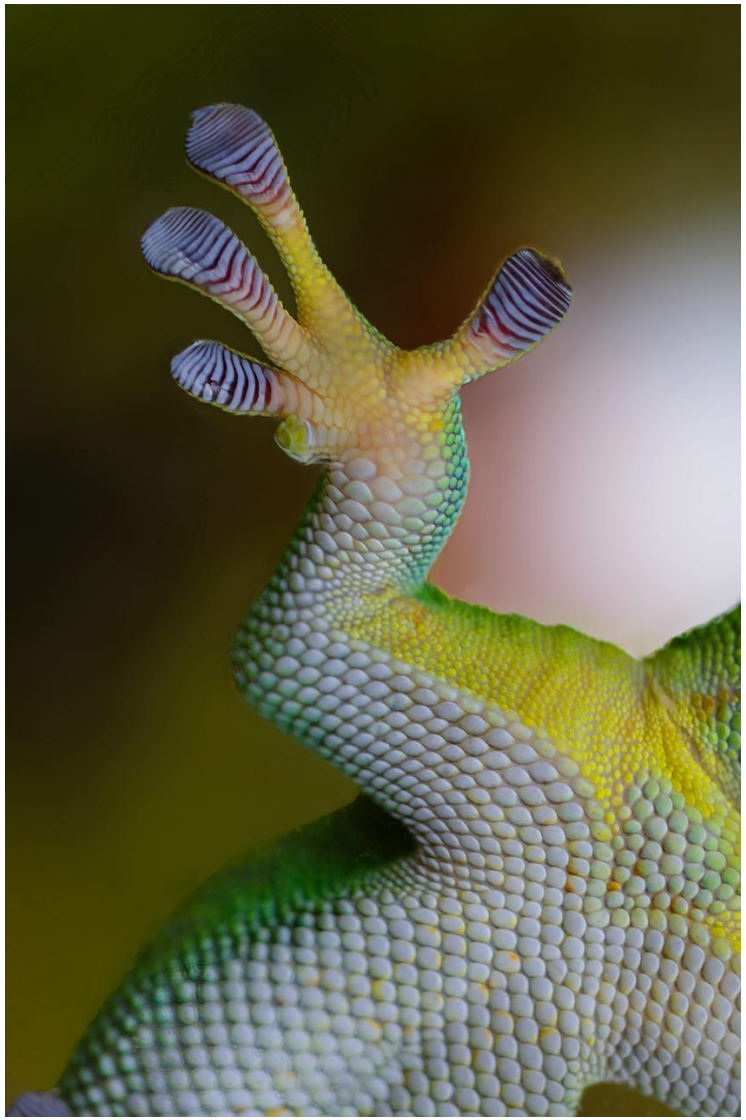
Bioispirazione in robotica: il caso del geco



Immagini tratte da: pixabay.com

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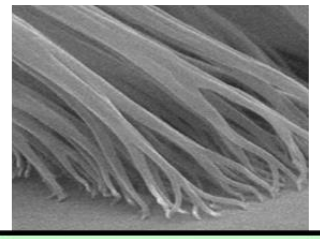
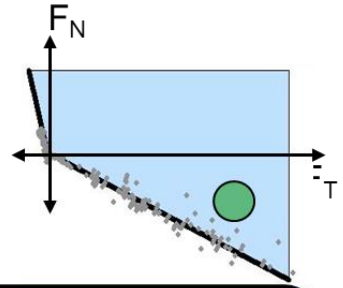
Bioispirazione in robotica: il caso del geco



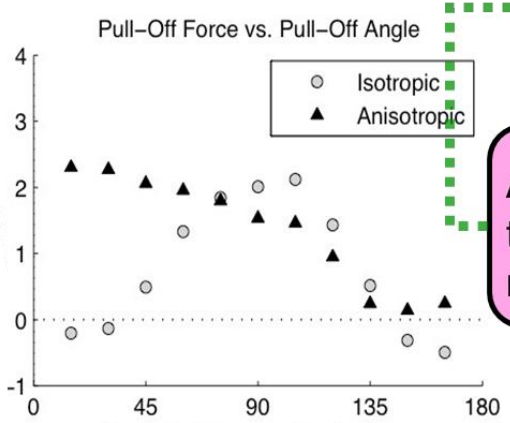


Bioinspiration
how do they do it?

Biology
examine literature, work with biologists

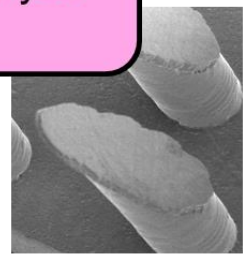
Hypotheses
regarding the principles at work

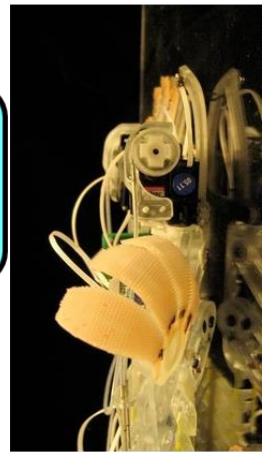
refinement



Analysis
test and analyze results

Robotics
implementations of principles





SDM technology

Slide courtesy of Prof. Mark Cutkosky, Stanford University

Bioispirazione in robotica: il caso del geco e del robot StickyBot

Video courtesy of Prof. Mark Cutkosky, Stanford University

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Bioispirazione in robotica: il caso del polpo e la nascita della robotica bioispirata “soft”

Courtesy of: The BioRobotics Institute, Scuola Superiore Sant’Anna. Photo credits: Massimo Brega

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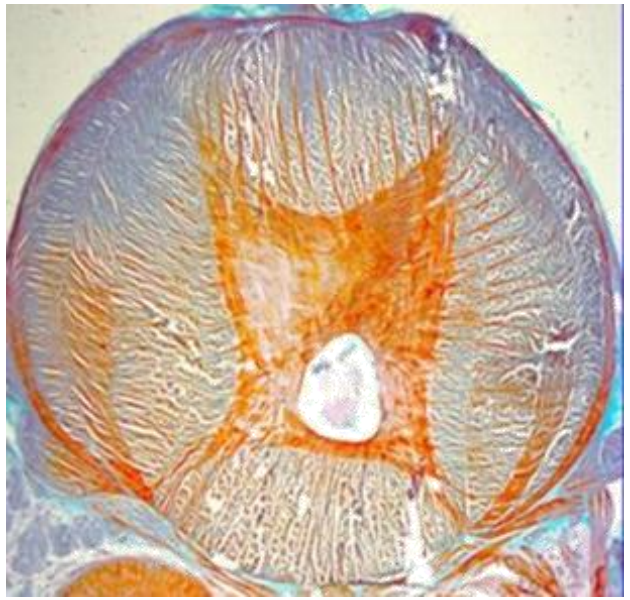

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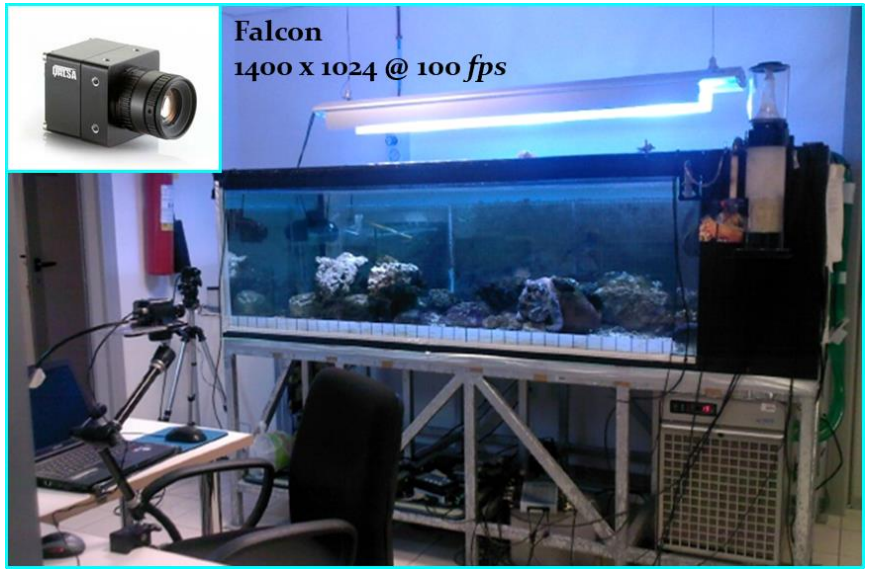

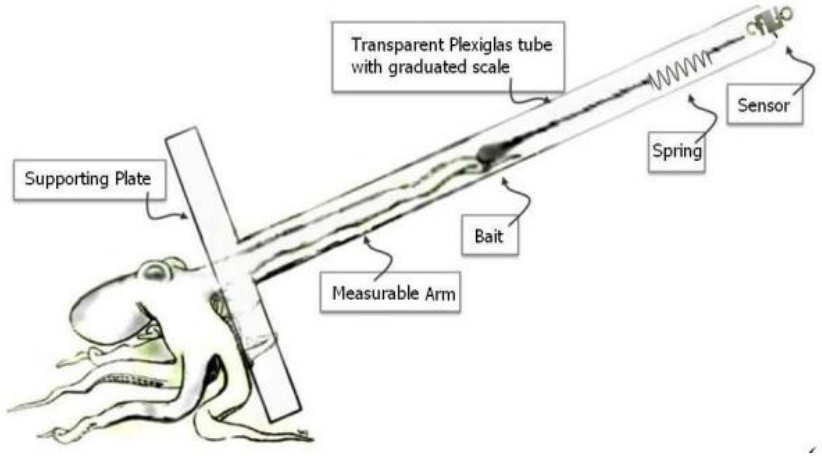

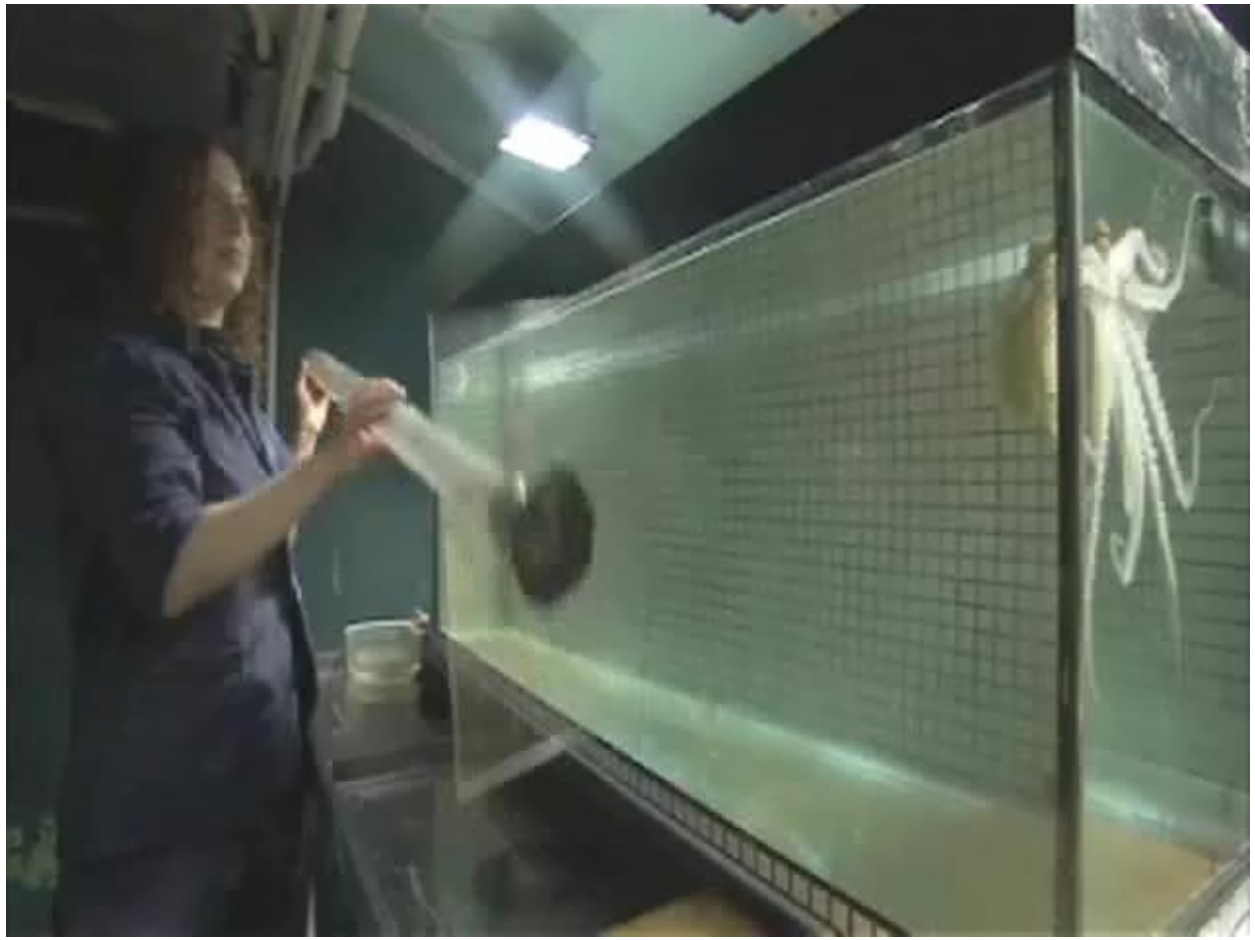

Margheri, L., Laschi, C., Mazzolai, B. (2012) Soft robotic arm inspired by the octopus. I. From biological functions to artificial requirements. Bioinspir. Biomim. Jun;7(2):025004

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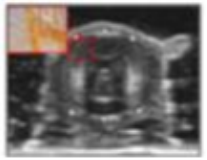
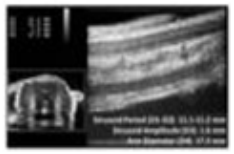
Dal naturale all'artificiale

		Biological Results (*Octopus vulgaris*)			Robotic Solution and Performance	Measure method
Transverse Muscles	Design Arrangement					**Ultrasound** (MyLabFiveVET@18MHz)
	Mechanical performance	70% of arm elongation corresponding to 23% of diameter reduction			Input to model for the design of SMA	**In vivo biomechanical measurement** (24 octopuses, 112 max elongations)
Longitudinal Muscles	Design Arrangement					**Histology** (Milligan-Trichrome staining)
	Mechanical performance	**Max Pulling Force**	**Mean Pulling Force**	**Time to contract**	-Longitudinal cables - Sheaths to reduce friction and avoid silicone damages - Calibration parameters (t,F)	**In vivo biomechanical measurement** (2 octopuses, 928 max of pulling force)
		49.8N@400mm (m=1600g) 26.8N@200mm (M=467g)	40N with arm length 400mm (100g)	1-2s		
		Mean Shortening	Stiffness	Shortening / Stiffening velocity		
		20%	9,5 x 10^5 N/m^2	17 mm/s		
Grasp Point Position		0.75 of total arm length			End effector position and active arm length	
Nerve Cord arrangement		Sinusoidal arrangement at the arm rest length while has a distension during the elongation 			Large elongations can be achieved using a sinusoidal arrangement for cables 	**Ultrasound** (MyLabFiveVET @18MHz)

Margheri, L., Laschi, C., Mazzolai, B. (2012) Soft robotic arm inspired by the octopus. I. From biological functions to artificial requirements. Bioinspir. Biomim. Jun;7(2):025004

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Biologia per la Robotica

Robotica per la Biologia

Video courtesy of: The BioRobotics Institute,
Scuola Superiore Sant'Anna
Credits: Massimo Brega, Kepach Production

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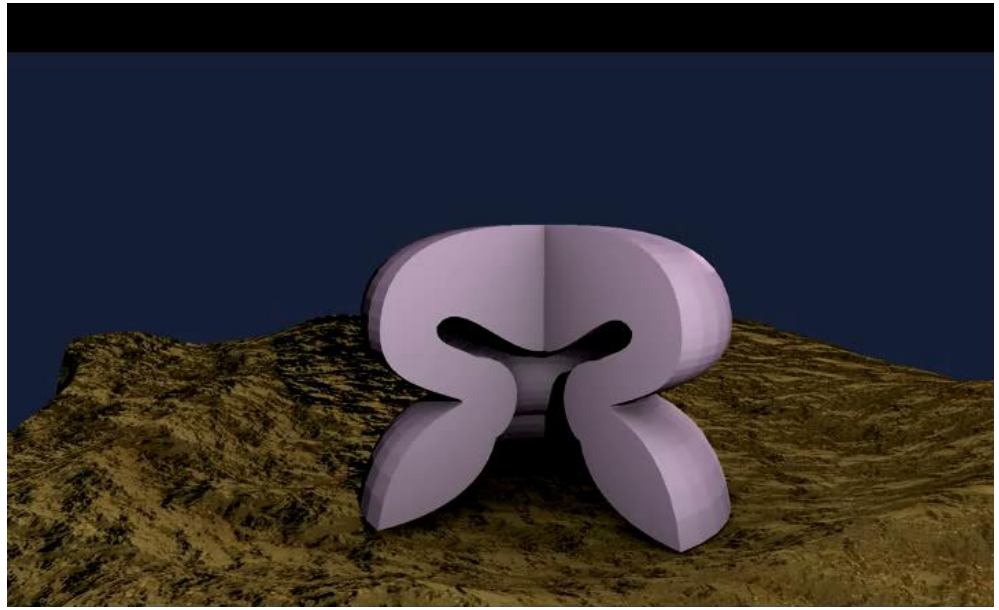
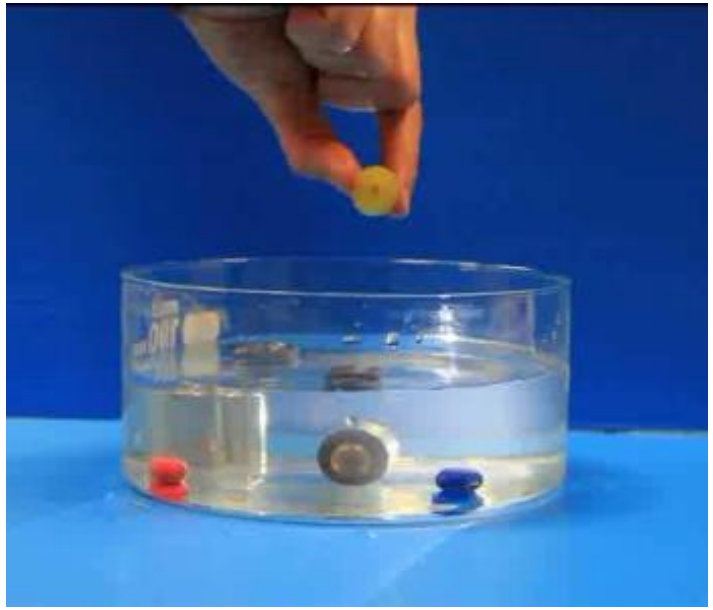
Immagine tratte da: pixabay.com

Lo studio del ruolo delle ventose





Tramacere et al. (2013) PLOS ONE;

Tramacere et al. (2014) Beilstein Journal of Nanotechnology

Tramacere et al. (2015) Interface Focus

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Adaptable soft arm for harsh environments

Adaptive grasping: self-adaptable soft arm with grasping capabilities for harsh environment

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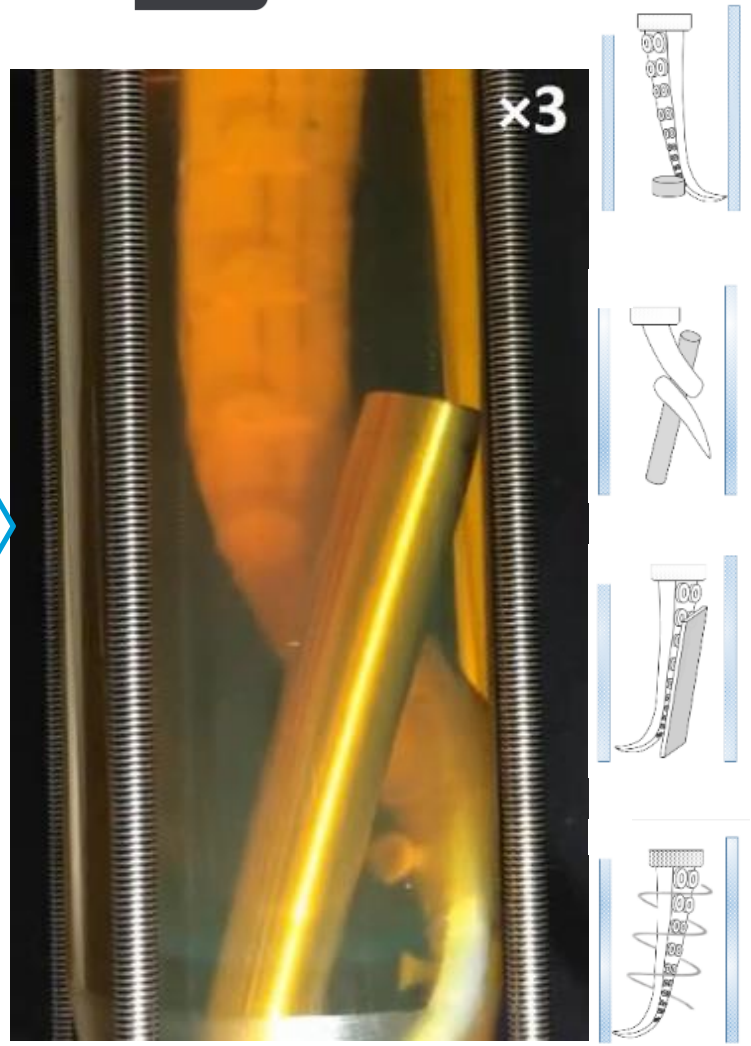
Design
Conical shape
370 mm length
30 mm maximum diameter
4.5 mm minimum diameter
9 suction cups

Materials
Fully soft
A softer skin (E = 0.07 MPa)
A stiffer core (E = 0.34 MPa)

Actuation
Tendon-driven actuation
Fluidic suction network

Control
Teleoperated system



Mazzolai at al. (2019) **Advanced Intelligent Systems**

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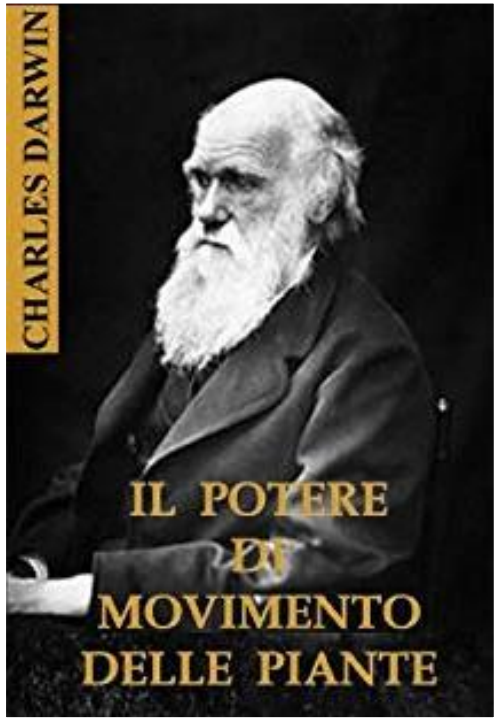
Il sorprendente regno delle piante



"Si è saputo di pietre che si son mosse, di alberi che hanno parlato"
William Shakespeare, Macbeth

Immagini tratte da: pixabay.com

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I Plantoidi

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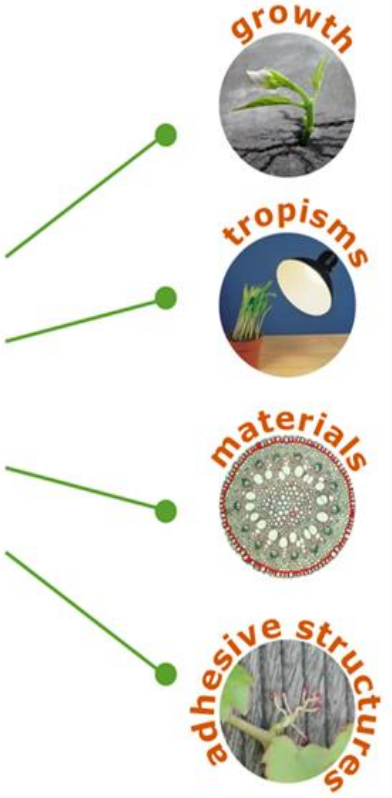
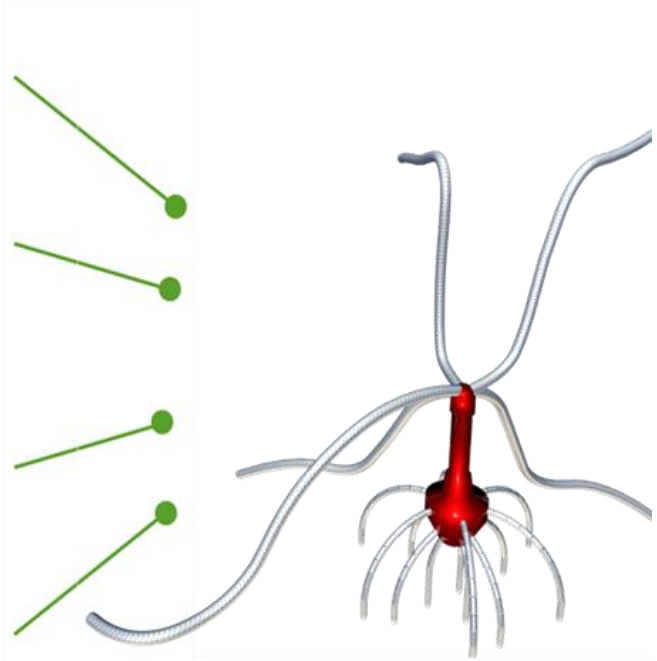
Il progetto GrowBot

"Movimento attraverso la crescita"

Coordinatrice: Barbara Mazzolai
https://www.growbot.eu/

Studiare la capacità di movimento, ancoraggio e crescita delle piante rampicanti per la realizzazione di nuovi robot che si muovono creando la loro struttura adattandosi e ancorandosi all'ambiente.



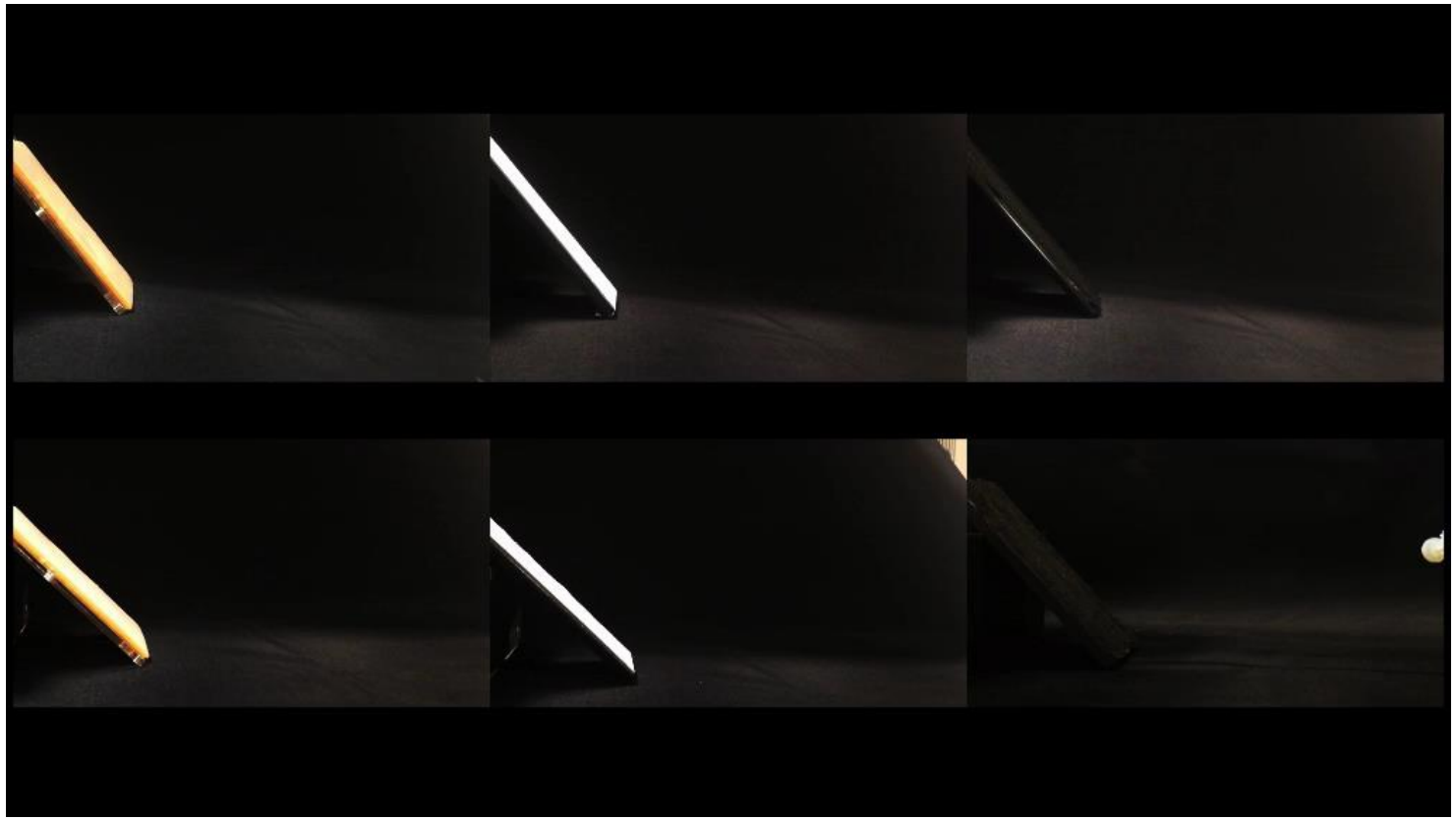


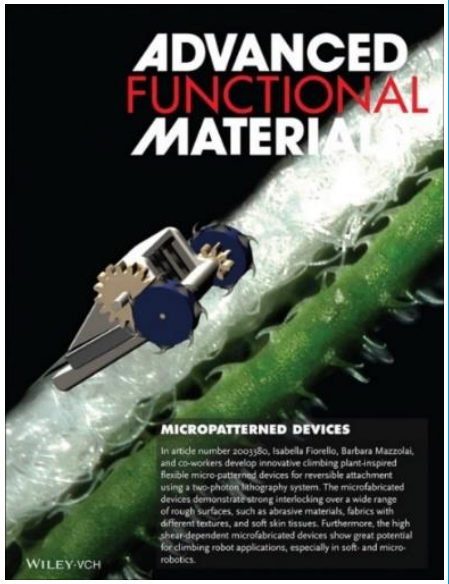
Micro-uncini per robot rampicanti

Pelle artificiale | Poliestere | Velcro

Senza uncini

Con uncini





Fiorello *et al.*, *Advanced Functional Materials* (2020);
Fiorello I. and Mazzolai B., I-RIM (2020);
Fiorello *et al.*, *Living machines (2018)*

Immagini tratte da: pixabay.com

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Dalle piante per le piante:
monitoraggio, cura, e agricoltura di precisione

Fiorello et al., Communications Materials, 2021

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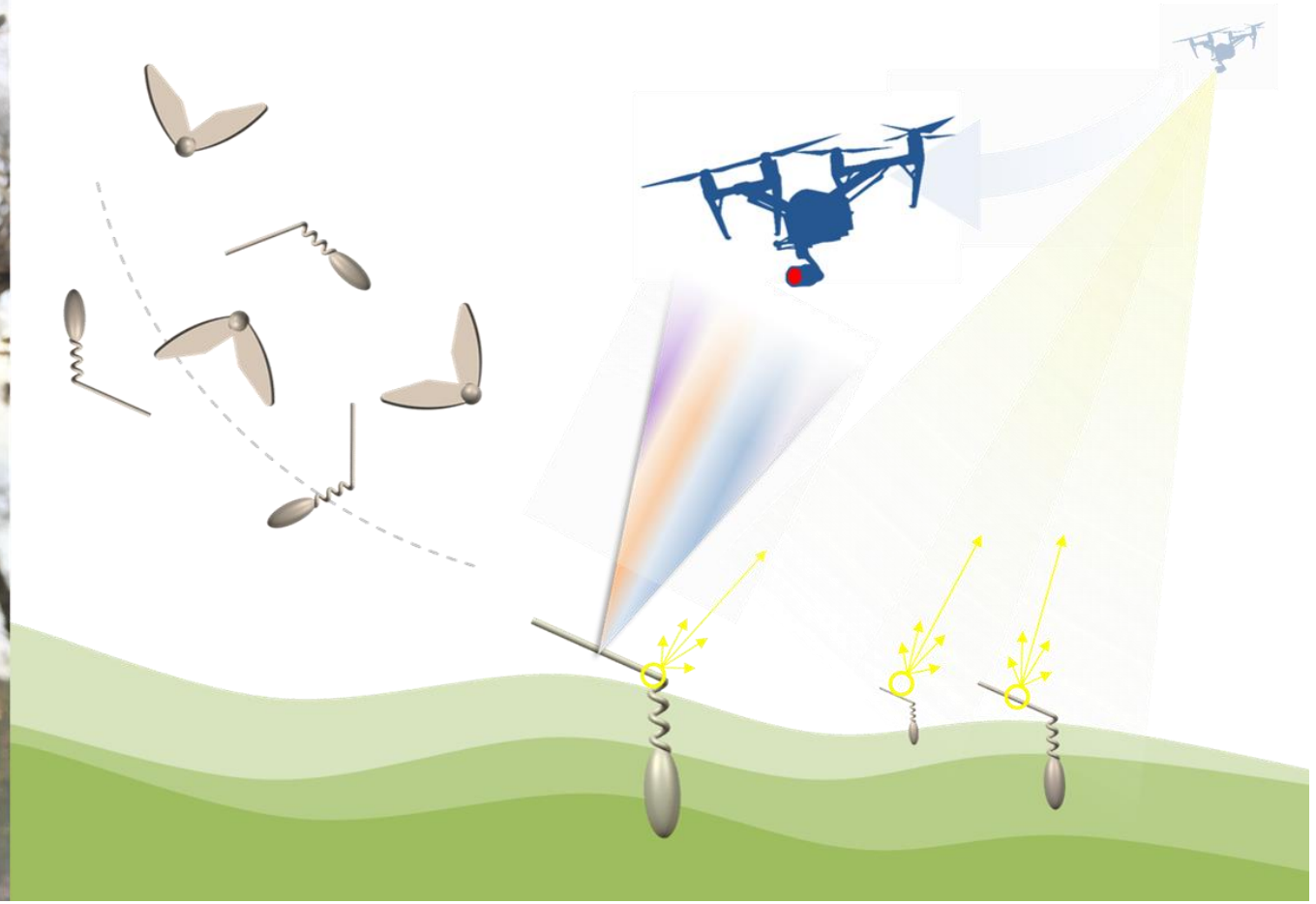
Il progetto I-Seed

Semi robotici biodegradabili per il monitoraggio ambientale

Coordinatrice: Barbara Mazzolai

www.iseedproject.eu



I-Seed

iit ISTITUTO ITALIANO DI TECNOLOGIA

INM Leibniz Institute for New Materials

CNR-IIA

Sant'Anna School of Advanced Studies – Pisa

WAGENINGEN UNIVERSITY & RESEARCH

OLYSEUS

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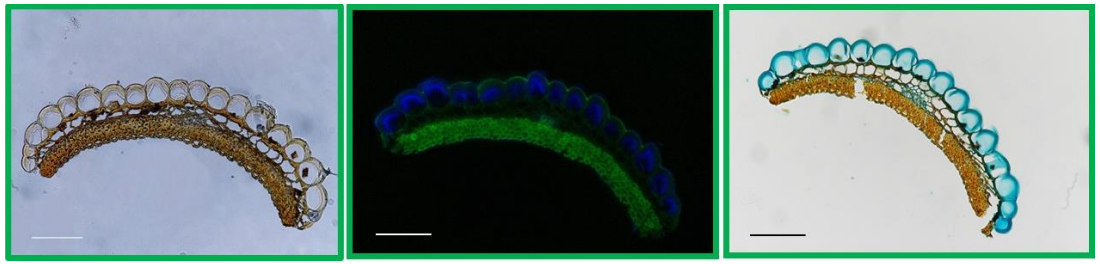
“Self-burial seeds”

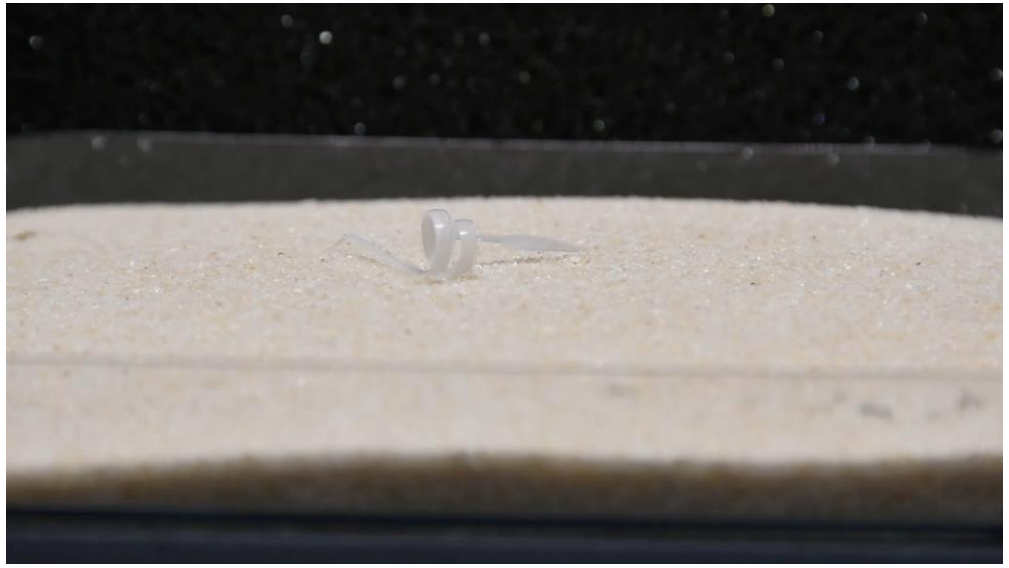
Semi in grado di muoversi e inserirsi nel terreno al variare dell’umidità

Pelargonium appendiculatum

Morphometry/Histology/Biomechanics



Dal naturale all’artificiale



Cecchini L, Mariani S, Ronzan M, Mondini A, Pugno N,* Mazzolai B*, 4D Printing of Humidity-Driven Seed Inspired Soft Robots,* ***Adv. Sci.*** *2023, 2205146*

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Nuove frontiere per il monitoraggio ambientale
Ecorobot biodegradabili soft




Immagini tratte da: pixabay.com

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La "mia" ingegneria

"Scopri cosa ti piace fare meglio e chiedi a qualcuno di pagarti per farlo" (Katherine Whitehorn)

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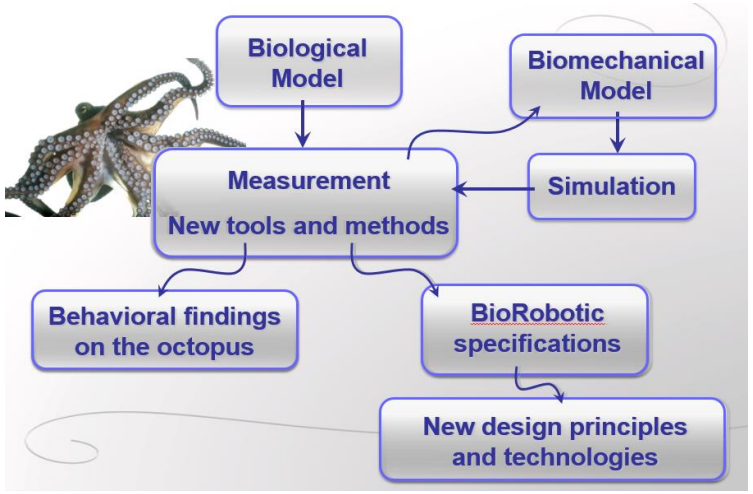
La bellezza della multi-disciplinarietà

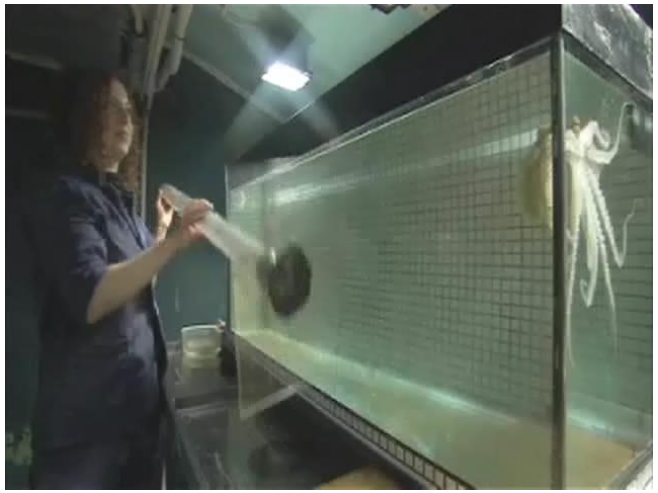
UNIVERSITÀ DI PISA
SCUOLA DI INGEGNERIA

BSc, MSc
Biomedical
Engineering

SCUOLA SUPERIORE SANT'ANNA
PISA

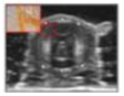
PhD
BioRobotics





Stazione Zoologica Anton Dohrn Napoli

מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

		Biological Results (*Octopus vulgaris*)			Robotic Solution and Performance	Measure method
Transverse Muscles	Design Arrangement					**Ultrasound** (MyLabFiveVET@18MHz)
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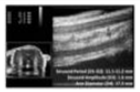
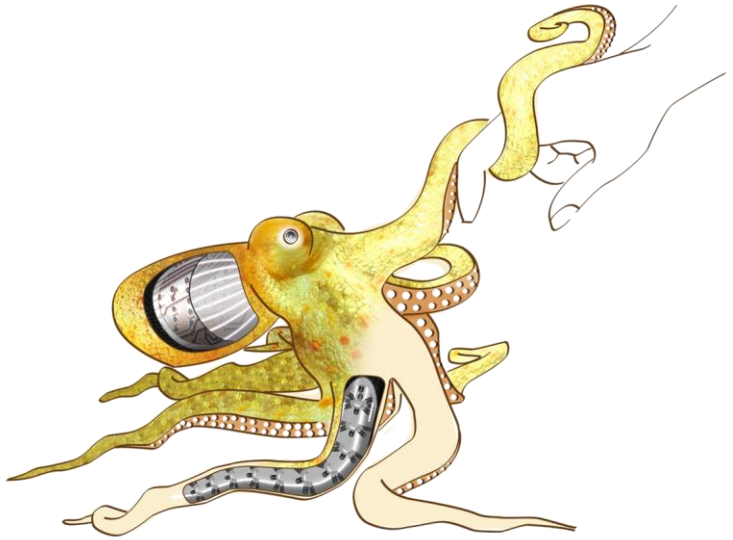
Nerve Cord arrangement		Sinusoidal arrangement at the arm rest length while has a distension during the elongation 			Large elongations can be achieved using a sinusoidal arrangement for cables 	**Ultrasound** (MyLabFiveVET @18MHz)



OCTOPUS

Robosoft

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Community building: le opportunità del fare network

IEEE Robotics & Automation Society

15000+ members
30 (co)-sponsored conferences
4 sponsored publications

2012 – 2013
Chair of the IEEE RAS
Students Activity Committee

2014 – 2015 + 2016 – 2017
Chair of the IEEE RAS
Women in Engineering Committee
IEEE WIE Society RAS representative

IROS 11
September 25-30, 2011
San Francisco, USA

IROS 2012
October 7-12
Vila Moura, Algarve [Portugal]

IROS2013
New Horizon
Tokyo

Seattle
ICRA 2015

icra STOCKHOLM 2016 SWEDEN
ICRA 2016 IEEE INTERNATIONAL CONFERENCE ON ROBOTICS AND AUTOMATION

IEEE ROBOTICS & AUTOMATION

WOMEN IN ENGINEERING

ICRA 2012
Robotic and Automation
Innovation for Tomorrow's Needs
MAY 14-18

KARLSRUHE
ICRA 2013

Hong Kong

ICRA2017
May 29 – June 3, 2017 • Singapore

Funding Robotics Projects: An Interview with Cécile Huet, Deputy Head of the European Commission Robotics Unit
By Laura Margheri

IEEE Women in Engineering WIE

IEEE women in engineering international leadership CONFERENCE

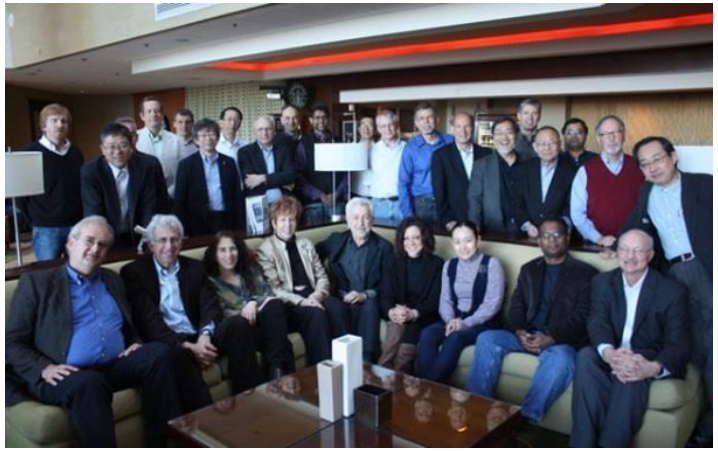
San Francisco 2014
San Jose 2015
Dubai 2016
San Jose 2017

Il Sole 24 ORE

Commenti&Inchieste ▸ Scenari

Le «donne- ingegnere» e la leadership al femminile

di Laura Margheri 31 maggio 2014



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Fare ricerca e supportare la ricerca

THE BIOROBOTICS INSTITUTE
Sant'Anna
School of Advanced Studies – Pisa

2012 – 2015
Scientific Secretariat/Executive Manager
of the Director of the BioRobotics Institute
Scuola Superiore Sant'Anna

Imperial College London

2016 – 2018
Programme Manager and Knowledge Transfer Fellow
@ Imperial College London, Aerial Robotics Laboratory
coordinated by Prof. Mirko Kovac

iit BSR
ISTITUTO ITALIANO
DI TECNOLOGIA
BIOINSPIRED SOFT ROBOTICS

2018 – ...
Post Doc @ Bioinspired Robotics Lab, IIT
Coordinated by Dr. Barbara Mazzolai

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Opportunità e scenari futuri della Robotica Bioispirata

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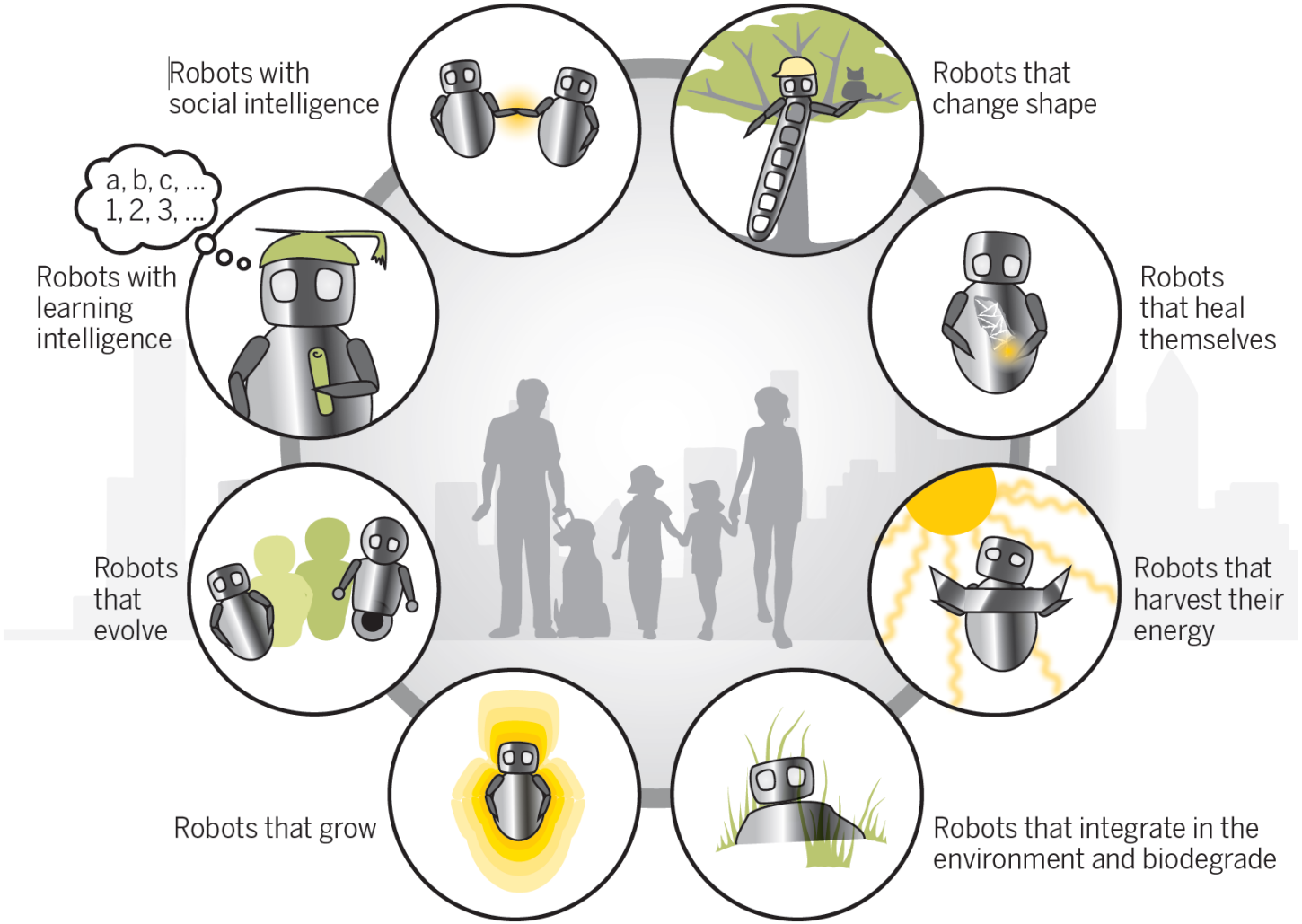
Verso una robotica sostenibile



Mazzolai and Laschi (2020) **Science Robotics**; Laschi and Mazzolai (2021) **MRS Bulletin**

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ISTITUTO ITALIANO DI TECNOLOGIA
BIOINSPIRED SOFT ROBOTICS

European Commission

erc

GROW BOT

I-Seed

esa European Space Agency

FENDI

REGIONE TOSCANA

eni

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Look deep, deep into nature, and you will understand everything better
Albert Einstein

Grazie

Scopri e iscriviti ai prossimi appuntamenti

https://professionigreen.deascuola.it/

Webinar

Matematica green: viabilità sostenibile e circolare

14 Marzo 2023, 17:00

con: Maya Briani, Alice Guerini Serena Giacomin

ISCRIVITI

Webinar con le classi

Professione green: complessità e trasversalità

15 Marzo 2023, 11:00

con: Teresa Agovino, Emilio Mancuso, Serena Giacomin

ISCRIVITI

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