Novel smart concepts for designing swimming soft microrobots

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Mobile Microrobotics

Potential applications

- navigation in **very narrow spaces** and **micro-structured liquid environments**
  - *in vivo* tasks for **diagnosis and therapy** in inaccessible districts of the human body (*e.g.* central nervous system and cardiovascular system)

→ **Cheaper, less painful and more flexible surgery**

Core issues

- what kind of motion is more adequate to the target working environment (**propulsion**)
- how can this motion be implemented (**actuation**)
- what kind of power source can be exploited (**power supply**)

→

Nowadays most pursued approach[2,4]

- **direct propulsion by means of an external source of energy** (e.g. magnetic field)
  - dramatic simplification of microrobots design and fabrication
  - complex and cumbersome external steering systems
  - limited possibilities to implement additional features

Novel Design Approach

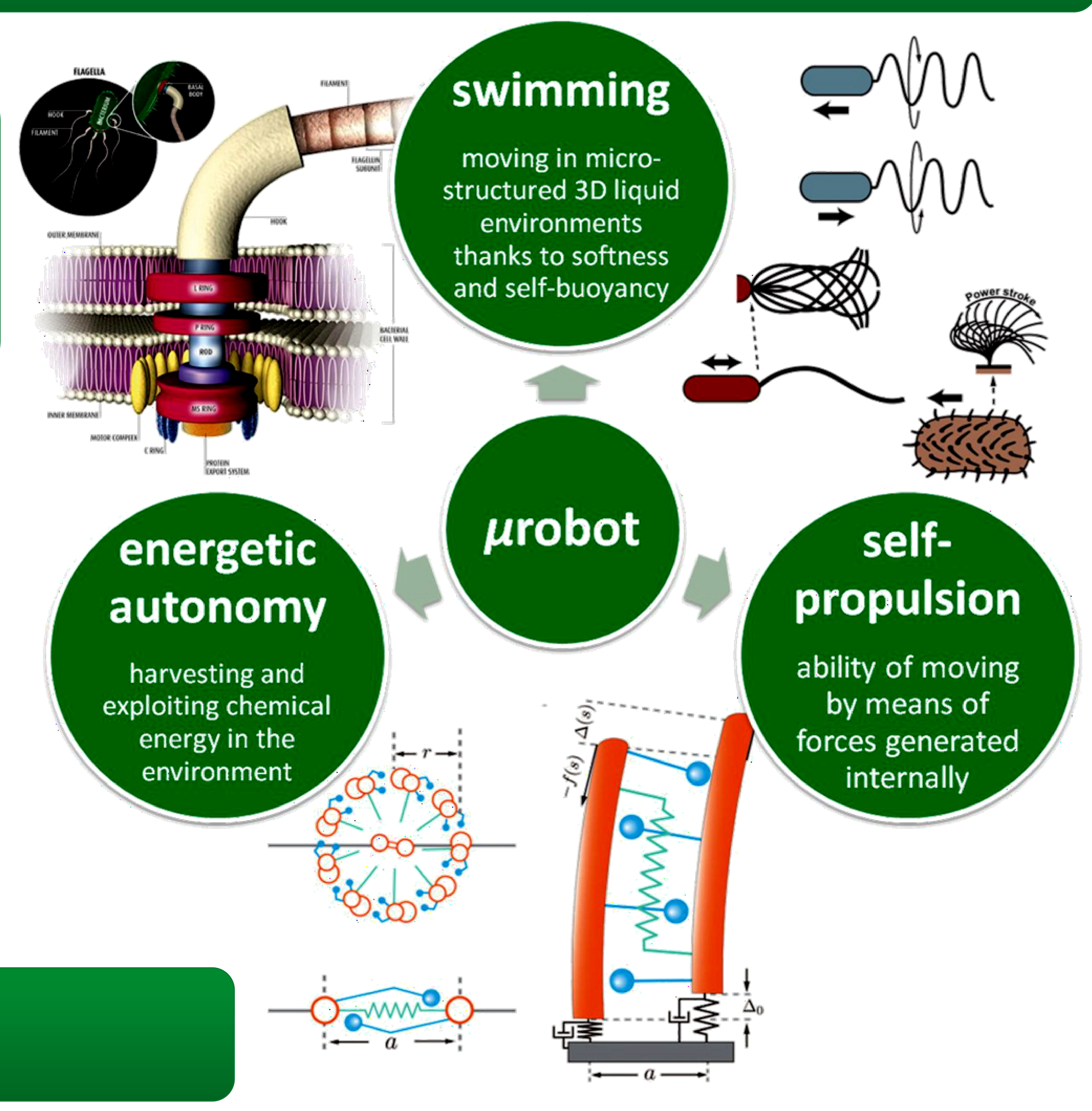
Smart microrobots

- systems expressing a high degree of **integration** of the different functionalities they implement at several levels of task accomplishment
  - **smart behaviors** provided by the **intrinsic passive and/or active properties** of the robot *per se*
  - proper selection of **materials** and microdevice **intrinsic architecture**

→ **Bioinspiration**[1,5] →

Our vision: microrobots

- **autonomously navigating** in human body environments
- **spontaneously reacting** to specific environmental conditions in order to perform **predetermined tasks**
- exploiting **environmental chemical energy** to power-supply embedded actuation systems



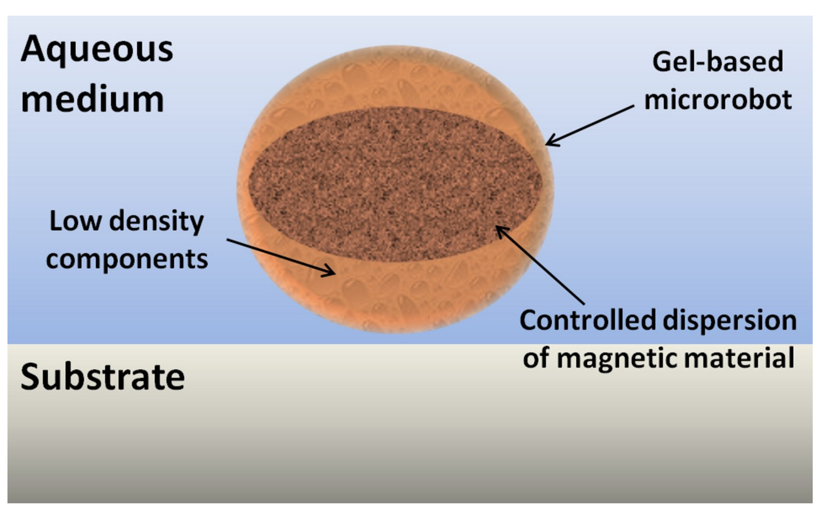
Preliminary Results

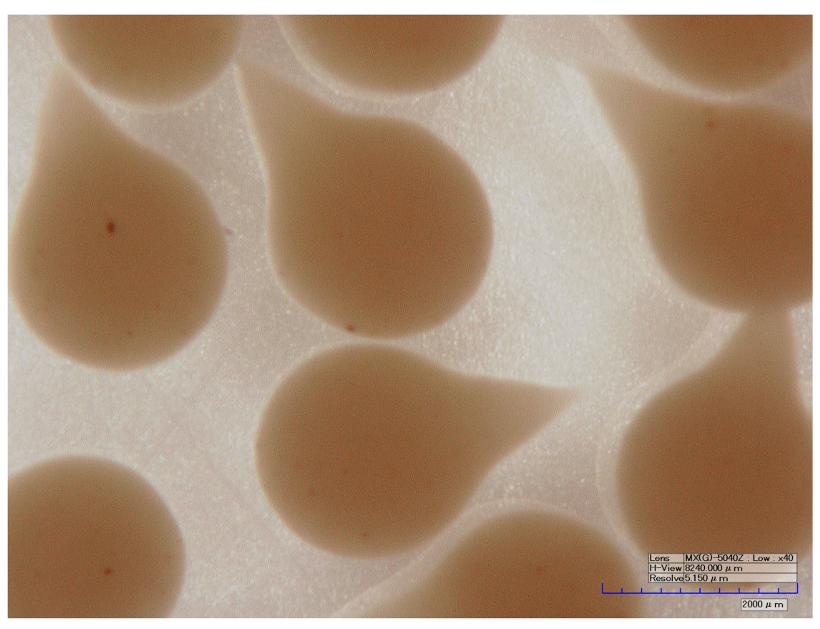
Softness

- hydrogel structure
- safe navigation in confined areas and ducts

Neutral buoyancy

- low density component in the structure
- complex external gravity compensation strategies avoided



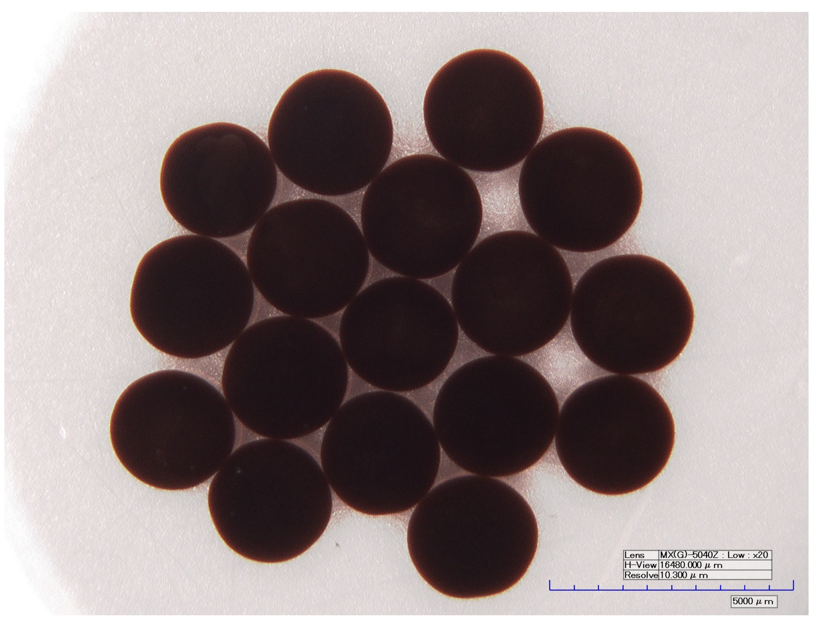


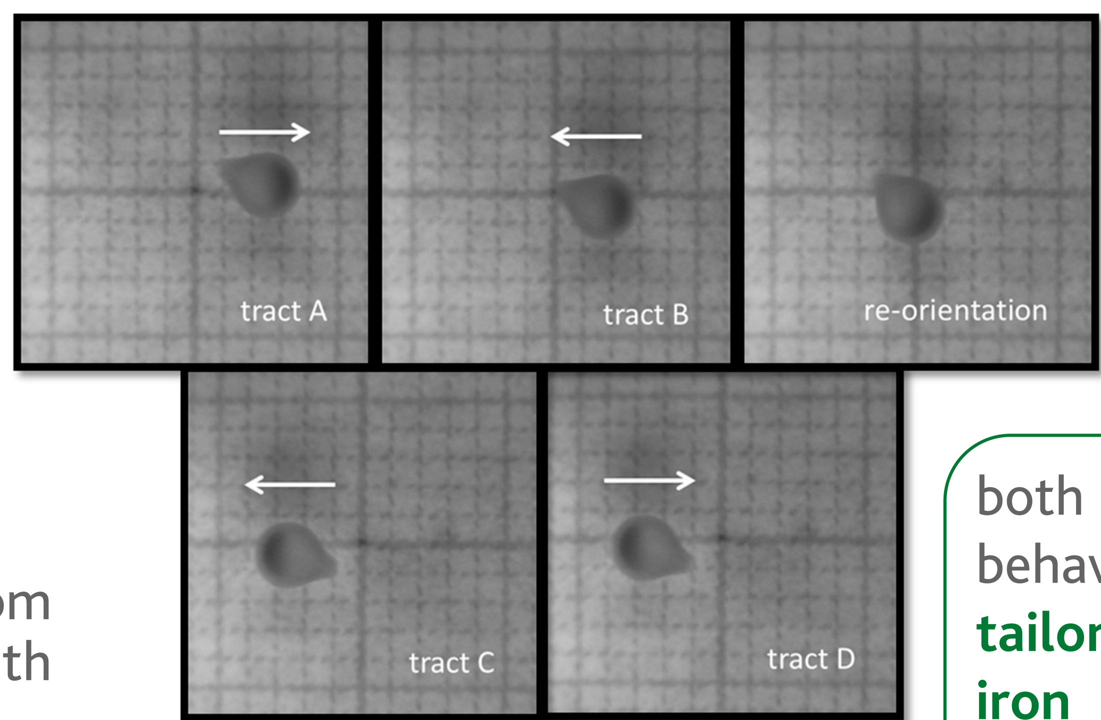
First objective[3]
Movement in liquid and delicate micro-structured environments

- implementation of **passive properties** of interest in **near-spherical** microdevices representing a **starting body structure** for building our microrobots
- investigation on how **different reactions to external fields\stimuli** can be implemented by properly selecting **materials** and controlling their **confinement** in the structure

Fabrication process

- **fast** & **simple**
- **inexpensive**
  - low cost materials
  - no special facilities required
- **scalable**
  - microdevices ranging from few millimetres to few tenth of microns in diameter





microrobots propelled at speeds of about 1 mm/s in water applying a 8 mT uniform magnetic field for orientation/magnetization and a 400 mT/m uniform magnetic field gradient for pulling

both **paramagnetic** and **ferromagnetic** behaviours achieved by embedding **tailored amounts and distributions of iron oxide nanoparticles** within the polymeric body

References

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