# BSC PROJECT INVITATION

SURGICAL ROBOTICS LABORATORY

www.surgicalroboticslab.nl

*SUPERVISOR: ISLAM S. M. KHALIL*

**Project title**: Actuation and Control of a Tetherless Electromagnetic Robot using Static Magnetic Fields

**Background**: In this project we will develop a miniature tetherless electromagnetic robot. This robot will consist of a tri-axial electromagnetic coils, embedded control system, power source, and an independent propulsion mechanism. The robot will be contained inside an electromagnetic configuration and static magnetic fields (Figure) will be used to achieve directional control and propulsion inside fluids characterized by low Reynolds numbers. The ultimate goal of this project is to demonstrate the capability of the miniature robot to swim controllably using static magnetic fields.


FIGURE : A miniature tri-axial electromagnetic coil will generate a controlled magnetic moment and its dipole will align along external magnetic fields.

**Tasks:**
- Model, design, and develop an autonomous electromagnetic robot under 2 cm in length
- Study the controllability of robot under the influence of a static magnetic field
- Motion control of the robot using visual feedback

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**Project title**: Localization and Control of IRONSperm

**Background**: IRONSperm is a hybrid micro-bio-robot powered by external magnetic field and actuated using passively propagated wave along its flexible flagellum. It consists of an organic body and magnetic coating. The organic body can be loaded with a drug, whereas the magnetic coating enables directions control and flagellar propulsion under the influence of controlled magnetic fields. In addition, the magnetic coating increases the echogenicity of the cells and enables minimally invasive localization (Figure). The ultimate goal of this project is to localize IRONSPerm samples using ultrasound feedback and achieve motion control using magnetic fields.

**Tasks:**

- Localization of IRONSperm using ultrasound feedback and optimize the contrast to noise ratio (CNR) in the ultrasound images
- Study the influence of the magnetic coating on the CNR and implement magnetic-based motion control

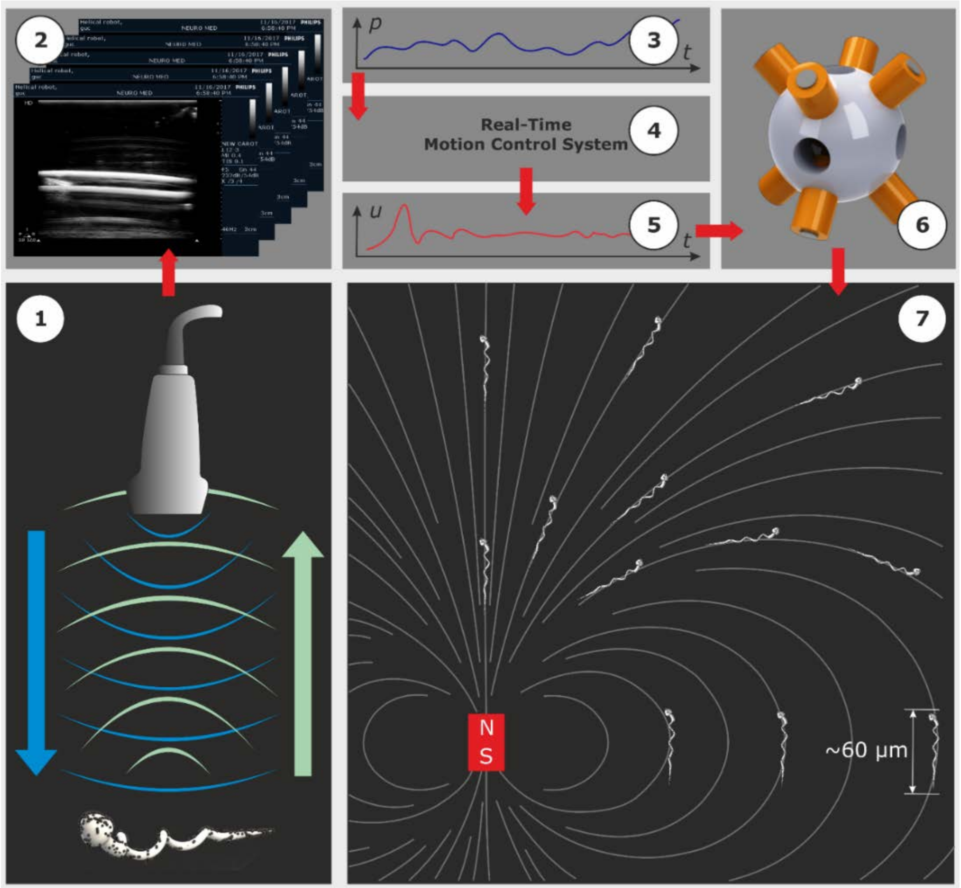


FIGURE : The magnetic coating of sperm cells enables localization and directional control using ultrasound feedback and under the influence of external magnetic fields, respectively.

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## *SUPERVISOR: ISLAM S. M. KHALIL*

**Project title**: Modeling and Control of a Swarm of Soft Microrobots

**Background**: Soft microrobots swim by passively propagated wave along an ultra-thin tail. Control of a single microrobot is not likely to yield the same efficiency as a group of microrobots. However, the travelling waves along their flagella are likely to influence each other. In this project, we will study the interaction between multiple beating flagella and the resulting wave-patterns. This study will allow us to understand how soft microrobots should swim in groups to improve the net thrust force.

**Task:**

- Modeling of a soft microrobot using the resistive-force theory and the regularized Stockeslets methods
- Modeling of groups of microrobots
- Experimental characterization of the swimming speeds in fluidic channels.

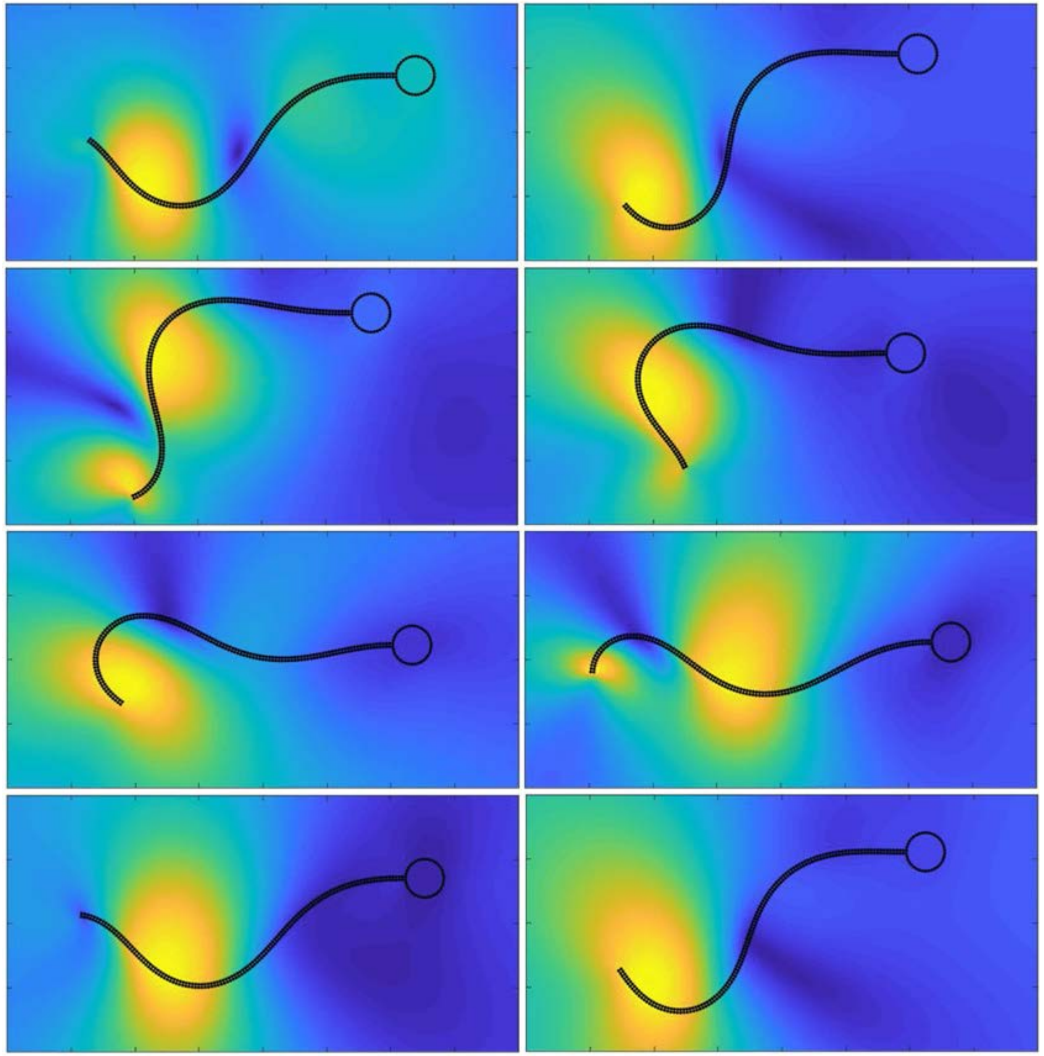

FIGURE : Soft microrobots swim by flagellar wave propagation.

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*SUPERVISOR: ISLAM S. M. KHALIL*

**Project title**: Fabrication, Modeling and Characterization of Soft Microrobots with Multiple Flexible Flagella

**Background**: Soft microrobots generate thrust by a beating flexible flagellum. To improve their thrust force, and consequently their ability to swim against the flowing streams of bodily fluids, additional tails are likely to improve their frequency response. In this project, we will investigate the influence of multiple flagella on the traveling-wave propulsion. The project will include theoretical and experimental work to characterize the thrust force of multiple flagella.

**Task:**

- Design and modeling of a soft microrobot with multiple flagella
- Fabrication and actuation of the microrobot
- Experimental characterization of the frequency response
- Characterization of the wave-pattern of each flagellum

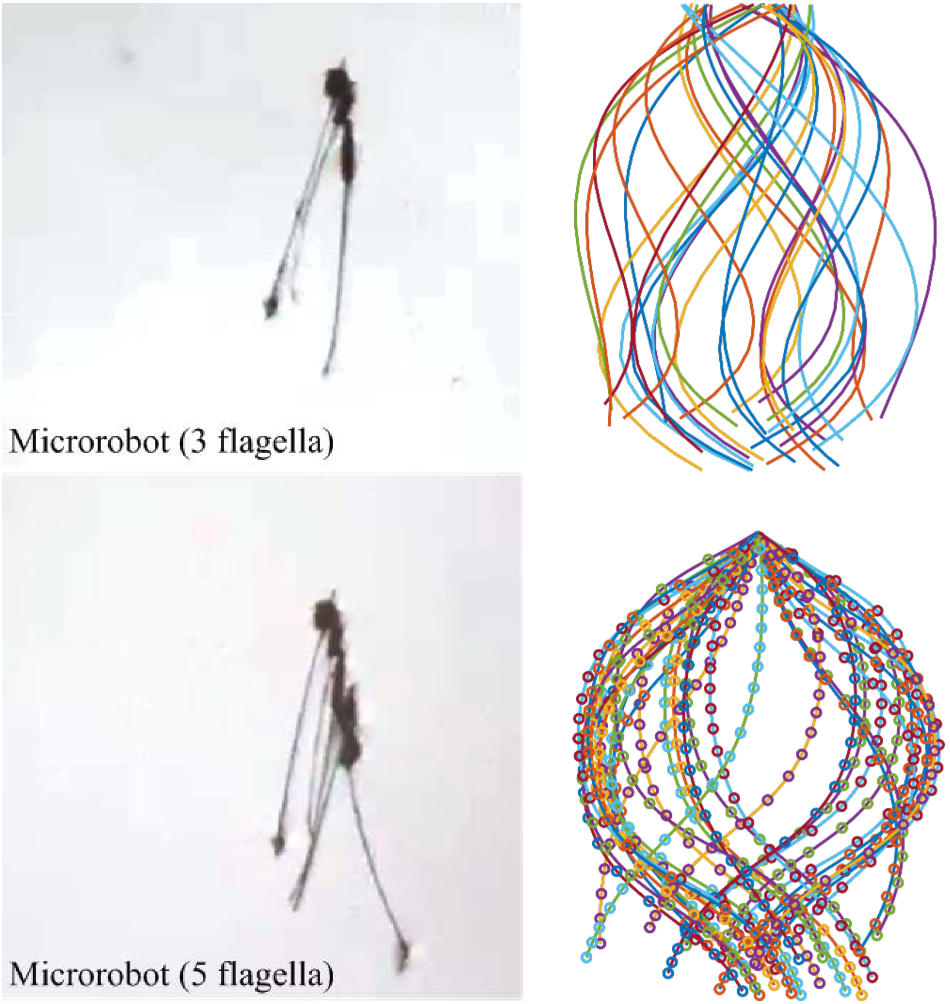


FIGURE : Soft microrobots with multiple flexible flagella

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# BSC PROJECT INVITATION

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**Project title**: Impacts of Bundling of Sperm on Flagellar Swimming in Viscoelastic Fluids

**Background**: Sperm clustering behaviour is observed in viscous fluids to increase the propulsive thrust (Figure). Single sperm cell swims by initiating transverse bending waves along the length of its flagellum to move the cell forward by pushing the fluid backward. In this project, we will study the influence of number of flagella on the net thrust force of the bundle. We will also study the interactions between the beating flagella and understand the optimal flagellar beat pattern of each flagellum.

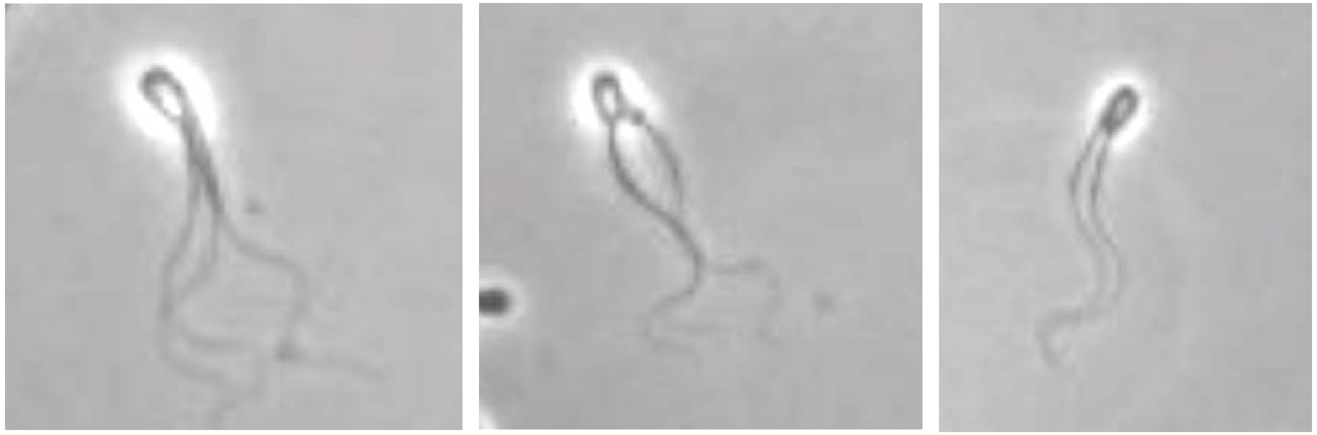

**Figure**. Sperm bundling behaviour is observed as the viscosity of the medium increases. Left: A bundle of three sperm cells swims by out-of-phase beat of its three flagella. Middle: A bundle of two sperm cells swims with out-of-phase flagellar beat of its two flagella. Right: A bundle of two sperm cells swims with in-phase flagellar bead if its two flagella.

**Task:**

1. Determine the influence of number of sperm cell per bundle on the net thrust force.
2. Determine if there exist an optimal synchronization pattern to enhance the propulsion.
3. Compare the swimming speed of single sperm cell and sperm bundle.

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