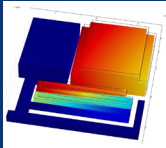
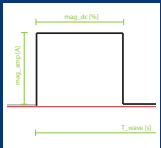


Design



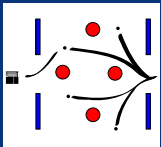
Design of mechanisms at this scale is a challenging endeavour. These devices are fabricated by iteratively either adding or removing material from a silicon wafer. At each step in the process, interactions between the various materials must be analyzed and planned. Along with manufacturing constraints, performance constraints are dictated by the robots end function. In particular, careful attention must be given to predicting the resonant frequencies of the drive system to enable the robot to be controllable.

Control



A digital camera system is used to track the microrobot as it moves. A computer then analyzes each frame to determine the position and orientation of the device. This information is compared with the desired pose and the difference is used as input for the control electronics. The robot has the ability to independently change its forward and angular velocities. The robot is a non-holonomic system because it is limited to moving along its drive axis.

Intelligence

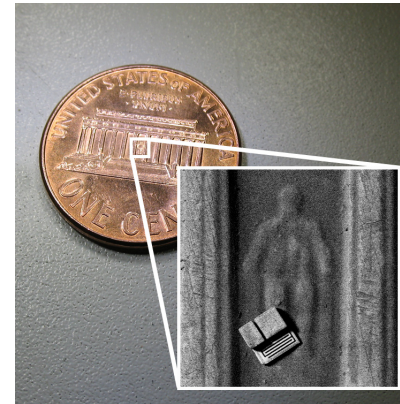


A high-level controller is responsible for deciding what the robot should do next. This system handles path planning and obstacle avoidance as the robot interacts with its environment. Although this controller is currently tailored to the Nanogram soccer competition, our goal is to eventually extend it to perform other tasks such as cell handling or swarm control of groups of robots.

What is a microrobot?

Microrobots are robotic agents with principle dimensions in the millimeter to micrometer range. Microrobots have been proposed for numerous applications ranging from *in vivo* biomedical therapy to military reconnaissance. These tasks require novel tools and sensors that operate at the microscale. Due to the scaling of physical effects, microrobots operate in a world that seems foreign to our intuition.

The microscopic world is governed by the same physical laws as the macroscopic world, but the relative importance of the physical laws changes. When we talk about scaling, we refer to some characteristic length of the device of interest. We then assume that all dimensions scale linearly proportional to that length. Volume is associated with inertia, weight, heat capacity, and body forces. Surface area is associated with friction, heat transfer, and surface forces. It is the balance between volume and surface effects that leads to many of the scaling issues important in microrobotics.



How does it work?

One of the primary challenges of building mobile microrobots is the design of the propulsion system. Due to difficulties in storing energy at these scales, mechanisms are needed for harvesting energy from the environment for wireless applications. Our robot harnesses the interactive forces between small magnetic bodies in a uniform magnetic field to drive the mechanism to resonance. This energy is then transformed to move the robot through its environment.

These small microrobots are capable of being driven forward, backward, and turning in place by changing the magnetic field. Although the robots are currently restricted to driving on flat surfaces, research is currently underway to develop aquatic versions of the robots.

These devices are some of the first in a series of micromechanisms that will enable researchers to interact in exciting new ways at this scale.

Who we are...



The Institute of Robotics and Intelligent Systems at ETH Zurich pursues a dynamic research program that maintains a strong robotics research focus on several emerging areas of science and technology. A major component of IRIS research leverages advanced robotics for creating intelligent machines that operate at micron and nanometer scales. IRIS research develops the tools and processes required to fabricate and assemble micron sized robots and nanometer scale robotic components.

Contact:

Institute of Robotics and Intelligent Systems
CLA H 17.1
ETH Zentrum
Tannenstrasse 3
CH-8092 Zürich

tel: +41 44 632 55 49
fax: +41 44 632 10 78
web: <http://www.iris.ethz.ch/msrl>