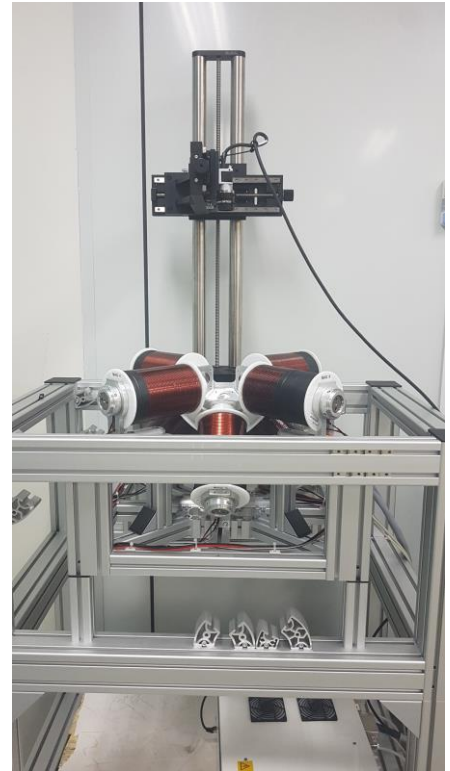


# OctoMag

## MagnebotiX mid-sized magnetic field and gradient control system

The MagnebotiX OctoMag comprises a magnetic field generation unit, power electronics, and a control software user interface (MBX Pro). The system is capable of generating arbitrarily oriented magnetic fields and field gradients within a spherical workspace having a diameter of approximately 50 mm. The system can thus levitate and control magnetic objects in viscous liquids with 5 degrees of freedom (3-DOF position, 2-DOF orientation). Time-varying signals can drive rotational or stepping-based actuation of magnetic objects. With our MBX Pro software and its ROS-based architecture, multiple control strategies are possible ranging from manual open-loop control to custom solutions for fully automated servoing of magnetic objects along predefined paths. The OctoMag is delivered with an outer frame that provides easy positioning in the lab. The inner, self-contained generator unit can be inclined at 0 (shown), 30 or 45 degrees to facilitate experimental access to the magnetic workspace, or can be placed independently of the outer frame in the laboratory.



### Field Generation and Control Modes

- *Field control*: generate an arbitrarily oriented field vector within the workspace for magnetizing ferromagnetic objects. Magnetic objects that can move freely will align with the external magnetic field.
- *Gradient control*: exert a force on magnetized objects to pull mobile objects in arbitrary directions along the field gradient or levitate objects in liquids
- *Rotational control*: controllably change the magnetic field orientation to exert a torque on a magnetized object, causing it to reorient if deflectable and rotate freely with the external field if mobile
- *User-specific control*: define fields and gradients as a function of time using standard mathematical notation: square wave, sawtooth, precessing field vector, exponentially decreasing – if you can define it mathematically you can generate with our new software.

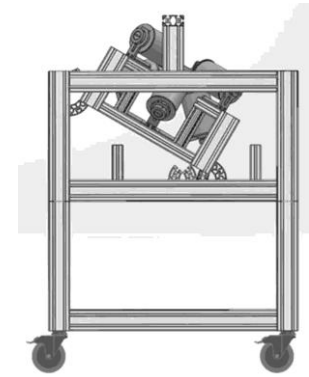
### Suggested Areas of Application

- Studies of magnetic microactuation strategies through the influence of magnetic forces and torques acting on small magnetic objects in air or liquids
- Mechanical manipulation and extraction of non-magnetic objects in liquids with the help of an untethered magnetic end-effector
- Studies on the mechanical properties of small objects through their interaction with an untethered magnetic end-effector
- Mechanobiology studies at the organ or small animal level measuring the response to small, untethered magnets, such as the determination of the viscoelastic properties of the vitreous humor *in vivo*.
- Catheter guidance for development of medical intervention techniques (e.g., automated panretinal photocoagulation, subretinal injections)

## System Components

### MagnebotiX OctoMag magnetic field and gradient generation unit

- Maximum working volume diameter: 5 cm
- Max. magnetic field strength (center): 50 mT in any direction
- Max. magnetic field gradient (center): 2 T/m
- Dimensions (field generator) W x D x H: 560 mm x 560 mm x 390 mm
- Weight (field generator unit) 125 kg
- Dimensions (outer frame) W x D x H: 640 mm x 940 mm x 1350 mm
- total weight: 180 kg
- inclination angle of field generation unit: 0°, 30° (shown), 45°
- The OctoMag magnetic field generator has no moving parts and can be used over a wide range of temperatures



### MagnebotiX extended power unit (ECB-820-ex)

- Number of channels: 8
- Max. current per channel: 18 A
- Max. voltage per channel: 96 V
- Max. magnetic field frequency: 10 Hz
- Max. power consumption: 2016 W
- External power requirements: 110 - 240 VAC / 50 - 60 Hz
- Dimensions (W x D x H) : 450 mm x 330 mm x 175 mm
- Weight: 12 kg
- Connection to control computer: Ethernet



The control computer and MBX pro software are included with the system.

System safety features: over-temperature and over-current monitoring of all coils; controller shutdown upon loss of communication with coil unit; external emergency shutdown switch.

The following are compatible with the system but not included

- Microscope or optics are chosen according to the experiments to be performed. Dissecting microscopes or long working distance zoom tubes are frequently used. A basic mounting platform is provided.
- Basler USB3 cameras are compatible with our MBX pro software (plug-and-play). Tested products include Basler USB3 ACE or Pulse series. Users can interface their own cameras through the open ROS environment if desired
- A computer monitor is not supplied with the system. We recommend use of a 24" monitor.
- SpaceNavigator (3Dconnexion), PlayStation3 controller (input is provided to the MBX pro control software for open loop control).

The principle of the magnetic field generating technology is protected by patents WO 2011029592 A1 and WO 2013127516 A1 to ETH Zurich and sub-licensed to MagnebotiX AG. For more details on the OctoMag systems see OctoMag: An Electromagnetic System for 5-DOF Wireless Micromanipulation, M. P. Kummer, J. J. Abbott, B. E. Kratochvil, R. Borer, A. Sengul and B. J. Nelson. IEEE Transactions on Robotics, **26** (6), 1006 – 1017, 2010.

The MBX pro control software is based on software originally developed in the Institute of Robotics and Intelligent Systems, Multiscale Robotics Lab, ETH Zürich ("daedalus") and has been adapted to the Robot Operating System (ROS).

*All specifications are subject to change without notice.*